DETRITAL ZIRCON GEOCHRONOLOGY OF MIDDLE ORDOVICIAN SILICICLASTIC SEDIMENT ON THE SOUTHERN LAURENTIAN SHELF

A Thesis

by

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Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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December 2012

Major Subject: Geology

ABSTRACT

Middle Ordovician (Whiterockian) sandstone units within the Oil Creek, McLish, and Tulip Creek formations of the Simpson Group of Oklahoma, and the Everton (Calico Rock Member) and St. Peter formations of Arkansas were deposited on the southern margin of Laurentia. They represent the first major siliciclastic input to the southern U.S. Midcontinent above the post-Sauk unconformity. Samples were collected from outcrops of the major sandstone units to determine their U-Pb detrital zircon age distributions for provenance. Samples were prepared and analyzed using laser ablation - inductively coupled plasma - mass spectrometry (LA-ICP-MS). Probability-density plots were created to determine likely source areas for sediment, based on comparing detrital zircon ages to known ages of basement terranes.

Detrital zircon grains from the Early Whiterockian Calico Rock sandstone indicate a majority of its zircon population was ultimately derived from the 900-1300 Ma Grenville orogenic province, with secondary input ultimately derived from the 1300-1550 Ma Granite-Rhyolite/Anorogenic Province and the Archean Superior province along the Transcontinental Arch. It is likely, at this time, that zircons were also sourced from reworked sediments from more proximal secondary sources. With sea level rise and transgression, the depositional shoreline and the sediment source areas moved to the north and west. The basal Oil Creek Sandstone of the Simpson Group was deposited unconformably above the Arbuckle Group in southern Oklahoma, and its zircon

population is dominated by grains from Archean source terranes along the Transcontinental Arch.

The basal sandstone unit of the McLish Formation indicates renewed sediment input containing zircons from 1300-1550 Ma Granite-Rhyolite/Anorogenic and 1600-1700 Ma Yavapai-Mazatzal terranes along the Transcontinental Arch. The Nemaha Ridge in northeastern Kansas likely acted as a source of first-cycle sediment in the southern midcontinent during this time.

Small populations of detrital zircon grains between 1800 Ma and 2000 Ma occur in the majority of the samples. Their probability density peaks are generally centered at roughly 1850 Ma, suggesting an ultimate source in the Penokean orogenic province along the Transcontinental Arch.

DEDICATION

I would like to dedicate this thesis, first and foremost, to my family, who encouraged me first to go back to school to study geology some years ago, and then to pursue a Master's degree. Both were the best decisions I've ever made, and I am grateful to my family for pushing me and believing in me, even in the tough times when I had a hard time believing in myself.

I am also greatly indebted to my friends, old and new. Especially those non-geologists who do a great job of pretending to understand (and care about) what I am talking about; those who took me in on the occasional weekend when I needed to not be in College Station; and who took care of my dog, Chewy, on short notice when I had to leave town for research. I could not have done this without you.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Mike Pope, for all of his help and guidance through the process of researching and writing this thesis, and for bringing me on as a student in 2010. It has been an incredible learning process, and I cannot thank him enough. I would also like to thank my committee members, Dr. David Schechter and Dr. Brent Miller. Dr. Miller's geochronology class was the foundation for my understanding what my research actually meant. I would also like to thank Dr. Renald "Ray" Guillemette, whose assistance with the imaging of zircon grains was invaluable.

I would like to gratefully acknowledge grants-in-aid from the Geological Society of America, the American Association of Petroleum Geologists, and the American Chemical Society (via Dr. Pope), which went to support field work, travel, and analysis.

I was assisted in the field by my friend Bryan Strong of Nautilus, USA on two occasions, over Spring Break and Thanksgiving Break, 2011. Bryan provided valuable insights and direction. I was assisted in the field in September 2011 by Frelynn Cohrs, also of Texas A & M, who, for a geophysicist, is a pretty darn good geologist. I was assisted in the lab by Mario Lira, an undergraduate research assistant working for Dr. Mike Pope. Mario prepared several of my samples, instructed me on sample preparation, and accompanied me to Washington State University (WSU) in Pullman, Washington in February, 2012, to blast zircons.

Andrew Hutto, Ben Workman, and Tracy Wulf preceded me in detrital zircon studies at Texas A & M, and were invaluable in providing me with direction. They overcame numerous obstacles, and watching and learning from their travails provided me with a much smoother ride. Andrew Hutto also accompanied me on a trip to WSU in October, 2011. It was cold and raining the whole time we were there, but it didn't matter because we were in a lab all the daylight hours.

I would like to thank the faculty in the Department of Geology and Geophysics and Petroleum Engineering, from whom I took classes. I am a vastly better geologist now than I was two years ago when I began working on my Master's degree.

I would also like to thank all of my friends in the Department of Geology and Geophysics here at Texas A & M. I made a lot of great friends while I was here, and their support helped to carry me through some very frustrating times.

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INTRODUCTION

The sandstones of the Middle to Late Ordovician Simpson Group of Oklahoma and the Everton and St. Peter formations of Arkansas were deposited coevally on the South Ozark Platform and Oklahoma Shelf, respectively, in a broad, shallow epeiric sea on the southern margin of Laurentia (Suhm, 1997). They are underlain by thick carbonate sequences of the Arbuckle Group in Oklahoma, and the Cotter and Powell formations in Arkansas; and overlain by Late Ordovician carbonates of the Viola Group and its lateral equivalents (Figure 1). These sandstones are distinctive for their overall homogeneity, being very clean (95% - >99% quartz), well-rounded, supermature, fine to medium grained quartz arenites (Ham, 1945; Suhm, 1997).

Deposition on the Oklahoma Shelf and South Ozark Platform in the Middle Ordovician was controlled by two major tectonic influences: uplift of the Ozark Dome, and continued subsidence of the Southern Oklahoma Aulacogen. The uplifting Ozark Dome routed sediment to the south and east in the late Whiterockian, and may have acted as a source of sediment (Suhm, 1997). Subsidence of the Southern Oklahoma Aulacogen slowed through the Ordovician, but it provided enough accommodation space to allow for deposition of the thickest shoreface and near-shore sandstone units in the Simpson Group (Suhm, 1997).

Sediment provenance for the Simpson, St. Peter, and Everton quartz arenites was attributed solely to the Canadian Shield (Dake, 1921; Suhm, 1997). Other possible sources of siliciclastic sediment include terranes exposed along the Transcontinental

Arch, such as the Yavapai-Mazatzal, Trans-Hudson, Penokean, Midcontinent Granite-Rhyolite, and anorogenic granites, as well as the Grenville orogenic province.

U-Pb geochronology of detrital zircon grains in quartz arenites has become a valuable tool for determining sediment provenance and aiding in paleogeographic reconstructions (e.g., Rainbird et al., 1997; Dickinson and Gehrels, 2009; Fan et al., 2011; Rainbird et al., 2012) . Advances in laser ablation - inductively coupled plasma - mass spectrometry (LA-ICP-MS) have reduced the amount of time required for analyzing zircon grains and determining crystallization ages (Hietpas et al., 2011).

Detrital zircon geochronology of the Paleozoic succession of the Ouachita facies, including the deep-water equivalents of the Simpson Group, Everton Formation, and St. Peter Formation, the Crystal Mountain, Blakely, and Womble formations (Krueger and Ethington, 1991; Suhm, 1997), indicates the sediment source for these units was dominantly Grenvillian, with lesser amounts from Granite-Rhyolite and Archean sources Shaulis (2010). Thermal ionization mass spectrometry (TIMS) of 21 detrital zircon grains from the Blakely Formation, in concert with neodymium isotope studies, indicate a Grenvillian-dominated age population, with a secondary Archean population and minor representation from the Granite-Rhyolite Province for sediment accumulated in the Ouachita Trough (Gleason et al., 2002). This study provides the detrital zircon geochronology of Middle Ordovician (Whiterockian) shelf sandstones of the southern Midcontinent of the United States. Five samples from Oklahoma, and four from

Arkansas, were collected and analyzed to determine changes in sediment provenance through the Whiterockian.

Geologic Setting

The South Ozark Platform and Oklahoma Shelf were located on the southern Laurentian shelf, in Arkansas and Oklahoma in the southern U.S. Midcontinent. In the earliest Whiterockian, the shelf area (Figure 2) was bordered to the north and northwest by a landscape dominated by karsted carbonates and possible eolian sand dunes, with the shallow shelf continuing eastward (Suhm, 1997). The shelf was rimmed on the south and southwest by the Southern Oklahoma Aulacogen, which began subsidence and infilling with sediment in the Cambrian (McConnell and Gilbert, 1990). To the south and southeast was the deep-marine Ouachita Trough. With rising sea levels, the shallow shelf covered most of the Midcontinent by the Late Whiterockian (Figure 3), with the Ozark Dome to the north of the South Ozark Platform the only large-scale positive feature (Suhm, 1997).

The sandstone units of the Everton Formation represent the first major siliciclastic influx onto the South Ozark Platform and Oklahoma Shelf following the Sauk-Tippecanoe unconformity (Finney, 1997; Suhm, 1974, 1997; Bunker et al., 1988; Sloss, 1963, 1988). The Calico Rock Member of the Everton Formation is the oldest areally-extensive sandstone unit of the Middle Ordovician in the southern Midcontinent (Figures 1 and 2), although there are isolated sand lenses within older Everton Formation units (Suhm, 1974, 1997). The Calico Rock Sandstone has a maximum thickness of about 60 m, averaging 20-25 m thickness over most of its extent (Suhm, 1975; 1997). Cementation is most often siliceous, with rare calcite and dolomite cementation (Suhm, 1974). The silica-cemented Calico Rock Sandstone is composed predominantly of fine- to medium-grained, subrounded, well-sorted quartz grains with common quartz overgrowths (Suhm, 1975). Where the Calico Rock Sandstone is carbonate-cemented, quartz grains are medium-grained, rounded to well-rounded, well-sorted, and frosted (Suhm, 1975). The Calico Rock Sandstone was deposited in a strand plain or advancing barrier-bar environment, with longshore currents carrying sediments to the southwest from a point source to the north (Suhm, 1975; 1997). Deposition extended to the south, into the Ouachita Trough, where coeval sedimentation likely formed the basinal Crystal Mountain Sandstone (Suhm, 1997).

Deposited coevally with the Calico Rock Sandstone on the Oklahoma Shelf, but of limited areal extent, is the carbonate-dominated Joins Formation, the basal unit of the Simpson Group (Schramm, 1965; Suhm, 1997). The Joins Formation was excluded from this study due to its poor exposure and lack of abundant siliciclastic sediment in outcrop (Denison, 1997).

As relative sea level rose, shoreline sandstone deposition back stepped northward (Figure 2). The Basal Oil Creek Sandstone was deposited on the Oklahoma Shelf and in the Oklahoma Basin northwestward of the Calico Rock shoreline, and reaches a thickness of over 100 m (Candelaria et al., 1997; Suhm, 1997). The up-dip equivalent of the Oil Creek Sandstone in northeastern Oklahoma and Arkansas is the Newton

Sandstone (Suhm, 1997). The sandstone in these units were deposited in barrier, back-barrier, and peritidal environments (Suhm, 1997). The Oil Creek Formation conformably overlies the Joins Formation where it is present, and unconformably overlies the Arbuckle Group where the Joins Formation is absent, as in the study area (Schramm, 1964). In the study area, sandstones of the Oil Creek Formation possess exceptional reservoir quality (>30% porosity, 1-2.5 Darcy permeability) due to excellent rounding and sorting of grains, and preservation of pore space by illite clay coatings of individual grains (McPherson et al., 1988; Denison, 1997).

At the base of the Simpson Group formations are major sandstone units (or conglomerate in the Joins Formation) with sharp basal contacts (Statler, 1965). The sandstone unit at the base of the Oil Creek Formation, the Basal Oil Creek Sandstone, grades upward into shale and carbonate, with scattered thin-bedded sandstone units (Ireland, 1965; Statler, 1965). These thin sandstone units are interpreted as stranded shoreface sandstones (Candelaria et al., 1997). This cyclic siliciclastic/shale-carbonate depositional pattern is repeated in the overlying McLish, Tulip Creek, and Bromide formations.

The Basal McLish Sandstone has a maximum thickness of 45 m, is composed of fine- to medium-grained, well rounded, frosted quartz grains, variously cemented by silica and carbonate. The Basal McLish Sandstone is a peritidal sand complex, with local channels cutting into the underlying Oil Creek Formation (Suhm, 1997). The Basal

McLish Sandstone was deposited further seaward of the Oil Creek sandstone (Figures 2 and 3), indicating it formed during a sea level lowstand (Suhm, 1997).

The shale and carbonate units of the upper portion of the McLish Formation grade eastward into the lowermost St. Peter Sandstone. In northern Arkansas, the St. Peter Sandstone was deposited disconformably on the Everton Formation (Craig, 1991). Quartz sand grains of the St. Peter Sandstone are well-rounded and well-sorted, and may record reworked eolian dune complexes flooded by transgressive seas (Dott et al., 1986; Suhm, 1997). This sediment was transported to the southwest via longshore currents as strandline sands (Figure 3), and deposited on the South Ozark Platform (Craig, 1991; Suhm, 1997). Upper St. Peter Formation sandstones in northern Arkansas are coeval with, and likely supply sediment to, the Tulip Creek Formation sandstone units in Oklahoma (Suhm, 1997). Nearshore shelf sandstones of the upper St. Peter Formation in northern Arkansas grade conformably upward into tidal flat facies of the Joachim Formation (Craig, 1991).

The Tulip Creek Formation is truncated in much of Oklahoma by the overlying Bromide Formation, being preserved only within the Southern Oklahoma Aulacogen, an area of relatively greater subsidence (Denison, 1997). The Tulip Creek Formation often is confused in the subsurface with the Bromide Formation, and is colloquially referred to as the "Third Bromide Sandstone" (Schramm, 1964; Suhm, 1997). It is composed of fine- to medium-grained, well-rounded, well-sorted quartz grains with siliceous or dolomitic cement (Suhm, 1997). Shale interbeds also occur within this unit, and shale fragments may be present within the sandstone beds (Cronenwett, 1956). The Basal Tulip Creek Sandstone (Figure 3) was sourced from the northeast, and dispersed southwestward via longshore currents (Suhm, 1997). This unit is interpreted as a broad stillstand shoreface sand (Dapples, 1955), or as a shallow-water subaqueous fan or delta system (Suhm, 1997).

Bromide Formation deposition represents the beginning of the Mohawkian Series of the Late Ordovician, coinciding with a decline in siliciclastic deposition in the study area (Schramm, 1964). The Bromide Formation has a similar cyclic depositional pattern to older Simpson Group units, but its basal sandstone units are more sporadically distributed (Suhm, 1997). Bromide Formation outcrops, where both the top and bottom of the unit could be definitively identified, were not observed and the Bromide Formation was not included in this study.

METHODS

Sample Collection

Samples of Simpson Group sandstones were collected in the Arbuckle Mountains of southern Oklahoma (Figure 4), at the base of three siliciclastic units, the basal sandstone members of the Oil Creek, McLish, and Tulip Creek formations, and tops of the McLish and Tulip Creek sandstone units. The Oil Creek Formation was sampled at the base of the formation (Figures 5a-b), immediately above the Arbuckle unconformity, in the US Silica Mill Creek quarry, south of the town of Mill Creek, Oklahoma (McPherson et al., 1988). The McLish and Tulip Creek formations were sampled in road cut outcrops along US Hwy 77, north of the town of Springer, Oklahoma, at locations identified by roadside markers erected by the Ardmore Geological Society (Figure 5c-f).

Samples from the base and top of the Calico Rock Member of the Everton Formation and the overlying St. Peter Formation were collected in the Ozark National Forest in northern Arkansas (Figure 4). The early Whiterockian Calico Rock sandstone is the oldest major sandstone unit deposited in the Southern Midcontinent following deposition of Cambro-Ordovician platform carbonates. It is the lowermost sandstone-dominated member of the Everton Formation (Suhm, 1974; 1975; 1997). Samples from the base and top of the Calico Rock sandstone were collected near the town of Calico Rock, Izard County, Arkansas (Figure 5g-h).

The St. Peter Sandstone occurs in outcrop or in the subsurface from the Upper Midwest to the southern Midcontinent. In the study area in northern Arkansas, onset of St. Peter deposition is roughly coeval with deposition of the McLish Formation of Oklahoma (Figure 1). Deposition of the uppermost St. Peter Sandstone in Arkansas is roughly coeval with deposition of the basal sandstone member of the Tulip Creek Formation in Oklahoma. The upper St. Peter Sandstone was collected south of the town of Allison, Stone County, Arkansas (Figure 5i; Craig and Deliz, 1988), and the Lower St. Peter Sandstone was collected near the Big Creek Bridge on Arkansas Hwy 14, Searcy County, Arkansas (Figure 5j; McFarland et al., 1979).

Detrital zircon samples of each unit in this study consisted of two one-gallon bags (5-10 kg) of rock fragments, collected from fresh outcrop. When the situation permitted, the samples were broken into approximately 3 cm x 3 cm x 2 cm, or smaller, fragments in the field. All hammers, picks, and chisels were cleaned in the field with wire brushes before and after sample collection.

Sample Preparation

All further sample preparation took place at Texas A & M University. Upon returning from the field, samples were washed to remove excess soil and sediment, as well as any biological material such as moss and lichen. Any remaining samples not yet reduced in size to fragments approximately 3 cm x 3 cm x 2 cm, or less, were broken with a 4- or 8-pound sledge hammer that was cleaned with soap and water and wire brushes between samples to prevent cross-contamination. These fragments were then processed through a jaw crusher, reducing the sample to rock chips no larger than approximately 2 cm x 1 cm x 0.5 cm. The resulting rock chips were then passed through a disc mill, which reduced the sample to particles no larger than medium-grained sand. These particles were then passed over a Wilfley table set at approximately 30°, which separated the grains based on density. This process separated heavy minerals, including zircon, from the bulk of the remaining sample which was dried and saved. Metal filings from the jaw crusher and disc mill, as well as any magnetic mineral grains in the sample, were removed with a neodymium-boron hand magnet. The remaining dense grains were then separated in liquid using methyl iodide (MEI). Denser minerals such as zircon pass through this liquid, whereas less dense minerals remain suspended. Zircon grains were then separated by hand, under microscope, from other dense mineral grains, such as apatite, garnet, rutile, tourmaline, titanite, and pyrite.

The separated zircon grains were then set in 1-inch diameter epoxy pucks. Three to four samples were set in each puck, along with two sets of standard zircon grains (Figure 6). Standards were provided by the Washington State University GeoAnalytical Lab, and included FC1 and Peixe, with accepted standard ages of 1099 Ma and 564 Ma, respectively. The epoxy pucks were lathed to approximately 5 mm thickness; sanded and polished with 6 μm, 1 μm, and 0.25 μm diamond grit; and carbon-coated, before being imaged with cathodoluminescence (CL) and back-scattered electron (BSE) using the Cameca SVX50 scanning electron microprobe in the Department of Geology and Geophysics at Texas A & M University. CL was used to image zonation within the individual grains, as well as fractures and pitting which could fascilitate lead loss from the crystal lattice. BSE was used to distinguish zircon grains from other heavy minerals that were not removed from the sample set. The BSE images were also used to create a numbered map of each sample set, which aided in the determination and tracking of analyzed grains.

Sample Analysis

The zircon grains were dated through U-Pb analysis by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) in the GeoAnalytical lab at Washington State University (WSU), Pullman, Washington. Ablation was accomplished using a New Age™ UP-213 (Nd-YAG 213 nm) Laser Ablation System coupled with a Thermo Finnigan Element 2™ inductively coupled plasma mass spectrometer. Samples were analyzed on two separate trips to WSU. Samples AS2, S5, CR, USSB, and TCT were analyzed in October 2011, with the laser set at a frequency of 10 Hz with an ablation diameter of 30 µm. Samples BC, BT, TM, and BM were analyzed in February 2012, with the laser frequency reduced to 5 Hz for all four samples to accommodate zonation (Vervoort, personal communication). The laser diameter was reduced to 20 µm for sample BM due to an abundance of smaller grains in the sample. Standard grains were analyzed between sets of 10-12 sample zircons.

Sample Size

Approximately 115 grains from each sample set were chosen for ablation, hopefully yielding a resultant population of greater than 100 useable grains. The sample populations were picked without regard to size, shape, or color, with only those grains which showed obvious zonation or pitting, cracking, or other damage purposely avoided. In general, 117 grains per sample are required to be analyzed to provide a 95% confidence of dating at least one grain of an age range representing more than 5% of the total population (Vermeesch, 2004). This approach focuses significance on clustered age groupings within the sample set, and may not identify minor components within the sample set with certainty (Gehrels, 2012). Post-reduction, the minimum useable grain population was 80 detrital zircon grains, in sample BC. A summation of grain populations for each sample and associated probabilities is located in Table 1.

Data Reduction

The LA-ICP-MS determined ^{238}U-^{206}Pb, ^{235}U-^{207}Pb, and ^{207}Pb-^{206}Pb ratios which were then cleaned and reduced following the methods of Chang et al. (2006) to yield probable ages, with uncertainties, for the analyzed grains. Ages determined with reference to the FC1 standard were found to be more concordant, overall, than those determined with reference to the Peixe standard. $^{207}Pb/^{206}Pb$ ages are considered more precise for "old" samples (>1.4 Ga) than are ^{238}U-^{206}Pb and ^{235}U-^{207}Pb ages (Gehrels, 2012). Because the majority of grains sampled (70%) were dated at >1.4 Ga, ages reported in this study are $^{207}Pb/^{206}Pb$ ages associated with the FC1 standard. Sample grains with greater than 10% discordance were culled from the final data set.

Wetherill Concordia diagrams (Figure 7) and probability-density plots (Figure 8) were created for each sample using Isoplot, a Microsoft Excel add-in developed by the Berkeley Geochronology Center (Ludwig, 2003). The probability density plot uses the determined ages and corresponding first standard deviations for grains in a given set to graphically represent sample probability distributions.

DATA

Probability-Density Plots

Age ranges of basement surrounding the U.S. Midcontinent are displayed on paleogeographic reconstruction maps (Figures 2 and 3), and are plotted graphically (Figure 9). These basement ages were compared with zircon ages represented in the probability density plots of each sample to determine possible ultimate source terranes for Ordovician quartz arenites in the southern Midcontinent. Table 1 provides a summary of populations for each sample. None of the samples in this study have detrital zircon grains younger than 900 Ma. Samples for each unit are discussed below, and are listed in general order of deposition.

The lower and upper portions of the Calico Rock Sandstone have similar probability-density profiles (Figure 8a). Both samples have their largest detrital zircon populations between 900 Ma and 1200 Ma (lower: n=42, 53%; upper: n=55, 59%), with an abrupt decrease in number of grains near 1200 Ma. The upper and lower Calico Rock samples both have distinct Archean populations between 2600 Ma and 2800 Ma (lower: n=22, 28%; upper: n=14, 15%) and Paleoproterozoic populations between 1350 Ma and 1550 Ma (lower: n=11, 14%; upper: n=20, 21%). The lower Calico Rock sample has a distinct, yet small, population of ~1600 Ma (n=2) and ~1850 Ma (n=2) zircons. The lower Calico Rock sample has single grains at about 2550 Ma and 2850 Ma. The upper

Calico Rock sample also has a small number of grains with ages of ~1650 Ma (n=2), ~1750 Ma (n=1), and ~1850 Ma (n=1).

The basal sandstone member of the Oil Creek Formation has three distinct populations (Figure 8b). The largest population occurs between 2600 Ma and 2900 Ma, centered at about 2700 Ma (n=78, 73%). There is a distinct population centered at about 1850 Ma (n=19, 18%), and another significant population between 1050 Ma and 1100 Ma (n=6, 6%). Single Paleoproterozoic grains occur at roughly 1950 Ma and 2050 Ma. Single Archean grains occur at about 2500 Ma and 3150 Ma.

Samples from the lower and upper portions of the basal sandstone of the McLish Formation have similar probability-density distributions (Figure 8b). Both samples have major Archean populations between 2650 Ma and 2900 Ma (lower: n=50, 60%; upper: n=60, 71%). Both samples have populations between 1300 Ma and 1450 Ma (lower: n=14, 17%; upper: n=12, 14%) and 1600 Ma to 1700 Ma (lower: n=11, 13%; upper: n=6, 7%), with minor 1750 Ma to 1900 Ma populations (lower: n=6, 7%; upper: n=6, 7%). Both samples have small populations between about 1000 Ma and 1200 Ma (lower: n=5; upper: n=3). There are no grains in either sample with ages between 1900 Ma and 2600 Ma.

The largest populations in both the upper and lower St. Peter Sandstone samples are Archean (lower: n=63, 63%; upper: n=45, 44%), with the majority of grains between 2600 Ma and 2800 Ma, and minor populations at 2900 Ma (n=2) in the lower sandstone, and 2500 Ma (n=2) and 2950 Ma to 3000 Ma (n=2) in the upper sandstone (Figure 8c).

The Upper and Lower sandstones of the St. Peter Formation have a large proportion of 1000 Ma to 1300 Ma grains (lower: n=26, 26%; upper: n=38, 37%). The Lower St. Peter sandstone has a moderate population concentrated at 1000 Ma to 1150 Ma (n=21), with minor populations at 1200 Ma (n=2) and 1300 Ma (n=3), and the Upper St.Peter sandstone has more 1000 Ma to 1250 Ma grains (n=35). Peaks in both samples are centered at about 1100 Ma. The Upper St. Peter sandstone has a larger population of 1300 Ma to 1500 Ma grains (n=15, 15%) than the Lower St. Peter sandstone, which has single grains at 1400 Ma and 1500 Ma. The Upper St. Peter sandstone has a small population of 1650 Ma to 1750 Ma (n=2), and 1875 Ma to 1975 Ma (n=2) grains. The Lower St. Peter sandstone has a small population of grains between 1800 Ma and 1900 Ma (n=8), but lacks any 1550 Ma to 1750 Ma grains. There are no detrital zircon grains in the Lower St. Peter sandstone sample between 1950 Ma and 2600 Ma, and the Upper St. Peter sandstone sample lacks grains between 2000 Ma and 2450 Ma.

Both the lower and upper samples from the Tulip Creek Formation have Archean populations centered at about 2700 Ma, with major concentrations between 2650 Ma and 2750 Ma (Figure 8b). The total Archean populations (lower: n=64, 66%; upper: n=69, 66%) include small peaks at ~2800 Ma (n=5) and 3000 Ma (n=2), single grains at 2550 Ma, 2950 Ma, and 3600 Ma in the lower sample; and a minor population between 2750 Ma and 2850 Ma (n=7), and single grains at about 2850 Ma and 2900 Ma in the upper sample. Both Tulip Creek Formation samples have substantial populations of 1000 Ma to 1200 Ma grains (lower: n=23, 24%; upper: n=19, 18%), in addition to small populations at about 1900 Ma (lower: n=3; upper: n=6) and between 1300 Ma and 1400

Ma (lower: n=2; upper: n=3). The lower sample has a minor population at about 1450 Ma (n=4), and the upper sample has a minor population at about 1500 Ma (n=2). Single-grain Paleoproterozoic populations occur at about 1950 Ma in the lower sample, and 1750 Ma, 1800 Ma, 2050 Ma and 2400 Ma in the upper sample.

Overlap, Similarity, and K-S Statistic

Three statistical methods are used to analyze the degree to which detrital zircon sample sets are similar or dissimilar: overlap, similarity, and the Kolmorgorov-Smirnov (K-S) statistic (Gehrels, 2012). These analyses were conducted using Microsoft Excel Add-in programs available via the website of the Arizona LaserChron Center, Department of Geosciences, University of Arizona (LaserChron).

Overlap measures the degree to which age clusters represented in a sample set overlaps with age clusters represented in multiple other sample sets, indicating the relative presence or absence of given population clusters (Gehrels, 2000; 2012). Overlap is presented on a scale of 0 to 1, with 0 representing no overlap in ages (the population clusters are not at all alike), and 1 being perfect overlap (population clusters in compared sets cover the exact same age windows (Gehrels, 2000; 2012). The samples in this study had a minimum overlap of 0.334, between the upper Calico Rock and lower Basal Oil Creek sandstones, and a maximum overlap of 0.870, between the upper and lower Basal McLish sandstones (Table 2). The mean overlap for the samples is 0.665, the median overlap is 0.671, and the 1-σ is 0.112.

The similarity measurement is also presented on a scale of 0 to 1. This measurement uses the sum of the square root of the product of a pair of probabilities to determine how similar two sets of data may be (Gehrels, 2000; 2012). A similarity value approaching 0 indicates a large difference in population size in similar population clusters in different sample sets; a similarity value of 1 shows perfect similarity, that is, similar proportions of overlapping ages (Gehrels, 2000; 2012). As with the overlap, the lowest similarity value in this study is between the upper Calico Rock sandstone and lower Basal Oil Creek sandstone (Table 3), with a value of 0.372, and the maximum similarity is between the upper and lower Basal McLish sandstones, with a value of 0.881. The mean similarity in the study is 0.724, the median similarity is 0.743, and the 1-σ is 0.102.

The K-S statistic measures the dissimilarity between two populations. The P-value is the probability that two samples are not statistically different, and ranges between 0 and 1. A P-value of >0.05 indicates a >95% probability that two compared samples are not different (Gehrels, 2012). This test is sensitive to the proportion of ages present within samples. Samples with perfect overlap can be shown with this test to not be sourced from the same area (with 95% confidence), simply because ages are present in different proportions (Gehrels, 2012). Consequently, the value of the K-S statistic is questionable for use in detrital zircon studies (Gehrels, 2012). K-S statistic values for the samples in this study (Table 4) range from 0.000 to 0.851. This large value occurs in comparison of the upper and lower samples of the Tulip Creek Formation. By the reasoning of the K-S statistic, it is not likely that these two samples share a common source, though their similarity value is greater than the median and mean similarity for the sample set.

DISCUSSION

Source Terranes

Ordovician siliciclastic sediment in the southern Midcontinent of North America was ultimately sourced from five major cratonic terranes (Figures 2, 3, and 9): 1) Canadian Shield/Superior Province, 2) Penokean/Trans-Hudson orogenic provinces, 3) Yavapai-Mazatzal provinces, 4) the Granite-Rhyolite Province and associated anorogenic granites of the central Midcontinent, and 5) the Grenville orogenic province. Detrital zircon grains older than 2.5 Ga are attributed to the Archean Superior Province (Dickinson and Gehrels, 2009). The Superior Province forms the bulk of the stable Archean craton of eastern Canada. The Trans-Hudson Orogen represents the suturing of the Superior Province to the Hearne and Wyoming cratons to the north and west between 1.78 Ga and 1.92 Ga (Whitmeyer and Karlstrom, 2007). 1.8-2.0 Ga grains are attributed to this orogenic event and its related juvenile crust (Dickinson and Gehrels, 2009).

The Penokean Province (1.835-1.875 Ga) comprises a belt of igneous and metasedimentary rocks extending from Minnestoa to northern Michigan (Van Schmus, 1976), and is roughly coeval with the Trans-Hudson Province (Whitmeyer and Karlstrom, 2007). The area covered by this terrane is relatively small compared to the adjoining Superior Province, but it is important due to its proximity to Middle Ordovician sediment dispersal pathways (Figures 2 and 3). Grains dated to roughly 1.85 Ga are attributed to the Penokean Province.

The Yavapai-Mazatzal Province consists of 1.7-1.8 Ga and 1.6-1.7 Ga juvenile crust assembled in two orogenic events at 1.71-1.68 Ga (Yavapai) and 1.65-1.60 Ga (Mazatzal), respectively, that stretch from the southwestern United States to the northern Midcontinent (Whitmeyer and Karlstrom, 2007). The orogenic events are generally combined when discussing sediment provenance. The coeval Labradorian Province of northeastern Canada is likely related to the Mazatzal province, and could also have acted as a source of sediment for the northern Midcontinent (Whitmeyer and Karlstrom, 2007). Detrital zircon grains dated to between 1.60 and 1.8 Ga are considered to be sourced from the Yavapai-Mazatzal Province, or possibly the Labradorian Province.

The Granite-Rhyolite province was accreted to the southeast margin of the Mazatzal province between 1.55 Ga to 1.3 Ga (Bickford et al., 1986; Van Schmus et al., 1996; Whitmeyer and Karlstrom, 2007). Associated 1.48-1.34 Ga granitic intrusives are dispersed throughout the Granite-Rhyolite Province, and throughout Paleoproterozoic crust to the north and west (Van Schmus et al., 1996; Whitmeyer and Karlstrom, 2007; Dickinson, 2008). Commonly thought of as anorogenic, these intrusives may be the result of continental arc magmatism or collision of juvenile terranes to the south (Whitmeyer and Karlstrom, 2007). Detrital zircon grains between 1.55 and 1.30 Ga are attributed to the coeval Granite-Rhyolite and anorogenic provinces.

The Grenville orogenic province was assembled on to the southern and eastern margins of Laurentia between 1.3 and 0.9 Ga, and marks the final assembly of the supercontinent Rodinia (Hoffman, 1991; Whitmeyer and Karlstrom, 2007). It is composed of multiple blocks sutured to Laurentia in multiple orogenic events, and sutured by intrusive granitoids (Corrigan and Hanmer, 1997; Whitmeyer and Karlstrom, 2007). Grenville-age basement rocks occur in the eastern Midcontinent of the United States, through the northeastern states into eastern Canada, and also occur in Texas (Whitmeyer and Karlstrom, 2007).

Sediment Provenance

Detrital zircon populations for the lower and upper Calico Rock sandstones are dominated by grains sourced from the 900 Ma to 1300 Ma Grenville orogenic province, with 53% and 59% of grains, respectively, of Grenville age. Both samples have similar secondary populations of grains sourced from the 1300 Ma to 1550 Ma Granite-Rhyolite/Anorogenic and >2500 Ma Archean Canadian Shield/Superior provinces. The lower and upper Calico Rock sandstones have relatively high overlap and similarity values of 0.774 and 0.825 (Tables 2 and 3), respectively, indicating a stable source area in eastern Canada throughout Calico Rock deposition.

The early Whiterockian transgression which moved the southern Laurentian shoreline northward also had an effect on sediment sourced to the southern Midcontinent. The Grenville-age sediment source which dominated Calico Rock deposition contributes only 6% of detrital zircon grains in the Oil Creek sample. The detrital zircon population in the Basal Oil Creek sandstone is composed predominantly (75%) of Archean grains sourced from the Superior Province of the Canadian Shield (Table 1). Archean grains are the dominant group in all younger samples in this study as well. A distinct peak in the probability-density curve at about 1850 Ma, represents sediment likely sourced from the Penokean orogenic province. There are no grains in the Oil Creek sample representing the Granite-Rhyolite/anorogenic or Yavapai-Mazatzal provinces. The provenance change from primarily Grenvillian sources during deposition of the upper Calico Rock sandstone to Archean sources during Basal Oil Creek deposition, which is qualitatively evident in comparison of the probability density diagrams (Figure 8), is further evidenced by the two samples having the lowest overlap (0.334) and similarity (0.372) values in the study (Tables 1 and 2).

In addition to the dominant Archean grain population, both the lower and upper samples from the Basal McLish sandstone have 1300 Ma to 1550 Ma populations (17% and 14%, respectively) representing the Granite-Rhyolite/Anorogenic Province, and 1600 Ma to 1700 Ma populations (13% and 7%, respectively) representing the Yavapai-Mazatzal Province. These detrital zircon grain populations were likely sourced from exposed basement rocks on the Nemaha Ridge in northeastern Kansas (Witzke, 1980), whose basement rocks are similar in age to those which sourced the McLish Formation samples in this study (Bickford et al., 1981). The McLish samples are the only samples in this study with significant 1600 Ma to 1700 Ma grain populations sourced from the Yavapai-Mazatzal Province. The two McLish samples have the highest overlap and similarity values for any pair of samples in the study (0.870 and 0.881, respectively; Tables 1 and 2), indicating relatively constant sediment sources during deposition of the Basal McLish sandstone.

The lower St. Peter Formation is coeval with the shale and carbonate succession of the upper McLish Formation and the lower Tulip Creek Formation sandstones (Suhm, 1997). Both the lower St. Peter Formation and lower Tulip Creek Formation samples have significant populations of 1000 Ma to 1300 Ma Grenville-sourced grains (26% and 24%, respectively). The lower St. Peter sandstone and lower Tulip Creek sandstone samples have an overlap value of 0.675 (Table 2), which is near the median of the sample set (0.671). However, the similarity in proportional distribution within the overlapping population is a relatively high 0.820 (Table 3). The upper St. Peter sandstone has significant populations of both Grenville (37%) and Granite-Rhyolite/Anorogenic-sourced grains (15%). This indicates a change in sediment supply away from Archean-dominated sources. When compared with the most Archean-dominated sample, the Basal Oil Creek sandstone (75% Archean), the overlap is 0.483 (Table 1), the second lowest overlap value in the study. The similarity value for the upper St. Peter sandstone and the Basal Oil Creek sandstone is also a comparatively low 0.607 (Table 2).

All samples have 1800 Ma to 2000 Ma populations of varying sizes representing derivation from either the Trans-Hudson or Penokean orogenies. However, within the total population, there are only five grains with ages between 1900 Ma and 2000 Ma. Where there is a distinct probability-density peak, in all samples the peak is centered at about 1850 Ma. This indicates that the majority of grains analyzed in this time interval are likely sourced either directly from the Penokean orogenic province, or from recycled sediments originally sourced from the Penokean Province. The Trans-Hudson orogenic province (1.8-1.9 Ga) was likely not a major contributor of sediment to the southern Midcontinent in the Whiterockian, whereas it provided much of the sediment for the Middle-Late Ordovician quartz arenites of western Laurentia (Pope, 2008; Baar, 2008; Wulf, 2011; Hutto, 2012; Workman, 2012).

Grain Recycling

The durability of zircon grains means they remain in the system with siliciclastic sediment as it is reworked in multiple cycles of sedimentation and deposition (Thomas, 2011). This is undoubtedly the case with at least some of the sediment analyzed in this study. There are few detrital zircon studies of late Precambrian and Cambro-Ordovician quartz arenites in the northern Midcontinent to compare with the samples in this study that could show direct sourcing and recycling from an existing quartz arenite. The Cambro-Ordovician Potsdam and Galway formations of New York contain predominantly Grenville sediment, with over 90% of zircon grains of Grenville age (Montario and Garver, 2009). Older grains are thought to be reworked from older sedimentary deposits, or sourced locally from minor outcrops of Archean basement (Montario and Garver, 2009).

Detrital zircon studies of Proterozoic quartz arenites in the northern Midcontinent have shown that large amounts of time and extensive transport distances are not required to produce supermature quartz arenites (Van Wyck and Norman, 2004). First-cycle quartz arenites are today being deposited in sub-equatorial environments of intense weathering, at latitudes similar to that of the Middle Ordovician southern Laurentian margin (Dott, 2003). It is possible that grains in the southern Midcontinent were directly sourced from the Archean Superior Province or from the Grenville Province. However, the presence of thick Proterozoic quartz arenites in the northern Midcontinent (e.g. quartz arenites of the Huron Supergroup), may suggest a multi-cycle history for many of the detrital zircons in this study. Though grains vary in size and sphericity, all grains analyzed in this study are well rounded.

Within the scope of this study, it is not possible to differentiate between first-cycle zircons and multi-cycle detrital zircon grains. Source terranes identified in this study are the ultimate sources of detrital zircon grains in the Ordovician quartz arenites. In most cases, these sources likely do not represent a direct sourcing of sediment from exposed basement rock. Further trace element analysis is required to determine the genetic relationships of zircons analyzed in this study to specific source regions with very similar ages (e.g. Penokean and Trans-Hudson orogenies), and to determine a more exact source region within a source terrane.

CONCLUSIONS

Detrital zircons from nine samples of supermature Middle Ordovician (Whiterockian) quartz arenites in the southern US Midcontinent were analyzed for U-Pb geochronology. Ages determined from this analysis were compared with known ages of North American basement terranes to determine sediment provenance. Changes in detrital zircon grain provenance indicate changes in geographic source area and source terrane.

Detrital zircon grains in early Whiterockian Calico Rock sandstones were sourced dominantly from the Grenville Orogenic Province, with secondary grain populations sourced from the Granite-Rhyolite/Anorogenic Province and Superior Province. As the sea transgressed, moving shelf siliciclastic deposition northward, the sediment source changed to one dominated by Archean grains from the Transcontinental Arch.

1600 Ma to 1700 Ma Yavapai-Mazatzal grains and 1300 Ma to 1550 Ma grains in the lower and upper Basal McLish sandstones are likely sourced from exposed Precambrian basement in northeastern Kansas along the Nemaha Ridge. In the study, this is the only clear evidence for direct input of first-cycle grains into the Middle Ordovician southern Midcontinent.

As relative sea level receded during deposition of the St. Peter Formation and coeval siliciclastic units, sediment supply patterns changed again, with increasing sediment of Grenville origin making its way to the southern Midcontinent.

Very little, if any, Middle Ordovician siliciclastic sediment in the southern Midcontinent was sourced from the Trans-Hudson Orogen. The majority of detrital zircon grains in this study between 1800 Ma and 2000 Ma are attributed to the Penokean orogenic source.

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APPENDIX A

FIGURE CAPTIONS

Figure 1: Stratigraphic chart for the study area in the southern US Midcontinent, with Ordovician series boundaries (Gradstein et al., 2004) and relative sea level curve (Haq and Schutter, 2008). Yellow colored units are sandstones sampled for this study. The relative stratigraphic locations of samples are denoted with a red circle. Grey areas indicate periods of erosion or depositional hiatus. Adapted from Suhm (1997), Gradstein et al., 2004), Haq and Schutter (2008), Bergstrom et al. (2009), and Webby et al. (2004).

Figure 2: Paleogeographic map of the US Midcontinent in the Early Whiterockian (Middle Ordovician), during deposition of Calico Rock and Oil Creek sandstones. Major sandstone units are colored in shades of yellow. Paleozoic basement provinces are color coded. Study areas are boxed. Adapted from Suhm (1997), Whitmeyer and Karlstrom (2007), Dickinson and Gehrels (2009). Paleoequator from Scotese (2004).

Figure 3: Paleogeographic map of the US Midcontinent in the Late Whiterockian (Middle Ordovician), during deposition of McLish, Tulip Creek, and St. Peter sandstones. Major sandstone units are colored in shades of yellow. Paleozoic basement provinces are color coded. Study areas are boxed. Adapted from Suhm (1997), Whitmeyer and Karlstrom (2007), Dickinson and Gehrels (2009). Paleoequator from Scotese (2004).

Figure 4: Map showing general locations of study areas (boxed), with sample locations marked with red circles.

Figure 5: Photographs of sample location sites. Arrow indicates direction up-section. Figures 5a-b: Sedimentary structures are visible in the Basal Oil Creek Sandstone as iron-bearing clay minerals are weathered. Figures 5c-f: Collection site for the lower Basal McLish Sandstone (5c; consolidated outcrop beneath float) , upper Basal McLish Sandstone (5d), lower Basal Tulip Creek Sandstone (5e; tip of arrow is pointing at in-place sandstone), and upper Basal Tulip creek Sandstone (5f; heavily bioturbated sandstone in sharp contact with shale) along US 77 north of Springer, Oklahoma. Regional dip in this area is roughly 55°-60° to the south. Contacts are denoted by the arrow tip. Figures 5g-h: Lower Calico Rock Sandstone (5g) and upper Calico Rock Sandstone (5h; hands sample), collected near the town of Calico Rock, Izard County, Arkansas. Figure 5i: Lower St. Peter Sandstone collected near Big Creek Bridge on Arkansas Hwy 14, Searcy County, Arkansas. The lower St. Peter Sandstone overlies the Everton Formation unconformably. Figure 5j: Upper St. Peter Sandstone, collected near the town of Allison, Stone County, Arkansas.

Figure 6: Image of zircon grains mounted in epoxy puck. The three circles are detrital zircon samples, and the two triangles are standard grains.

Figure 7: Example of a Wetherill Concordia diagram from sample AS2, the Upper St. Peter Sandstone.

Figure 8: Probability-density plots for the nine samples included in this study, in general stratigraphic order (i.e., units represented by plots in Figure 9a were deposited before those in 9b, and those in 9b were deposited before or coevally with those in 9c). Samples collected in Oklahoma are on the left (Figure 9b) and Samples from Arkansas are on the right (Figures 9a and 9c). Figure 9a: Probability-density plots for the upper and lower Calico Rock Sandstone of the Everton Formation. Figure 9b: Probability density plots for sampled intervals of the Simpson Group. Figure 9c: Probability-density plots for Upper and Lower St. Peter Formation.

Figure 9: Age key for source terranes for probability-density plots. Ages from Whitmeyer and Karlstrom (2007), Dickinson (2008), and Dickinson and Gehrels (2009).

APPENDIX B

FIGURES

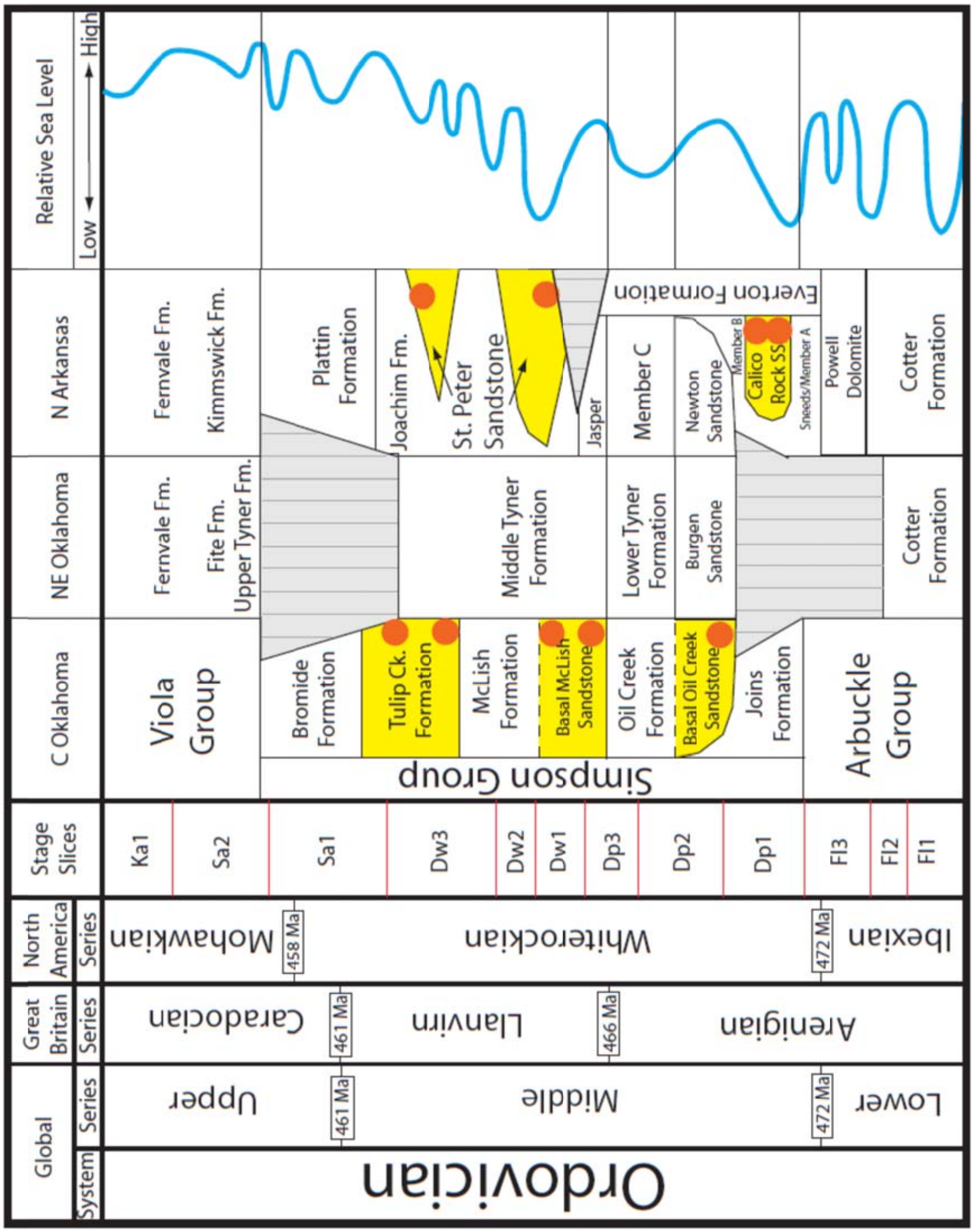


Figure 1

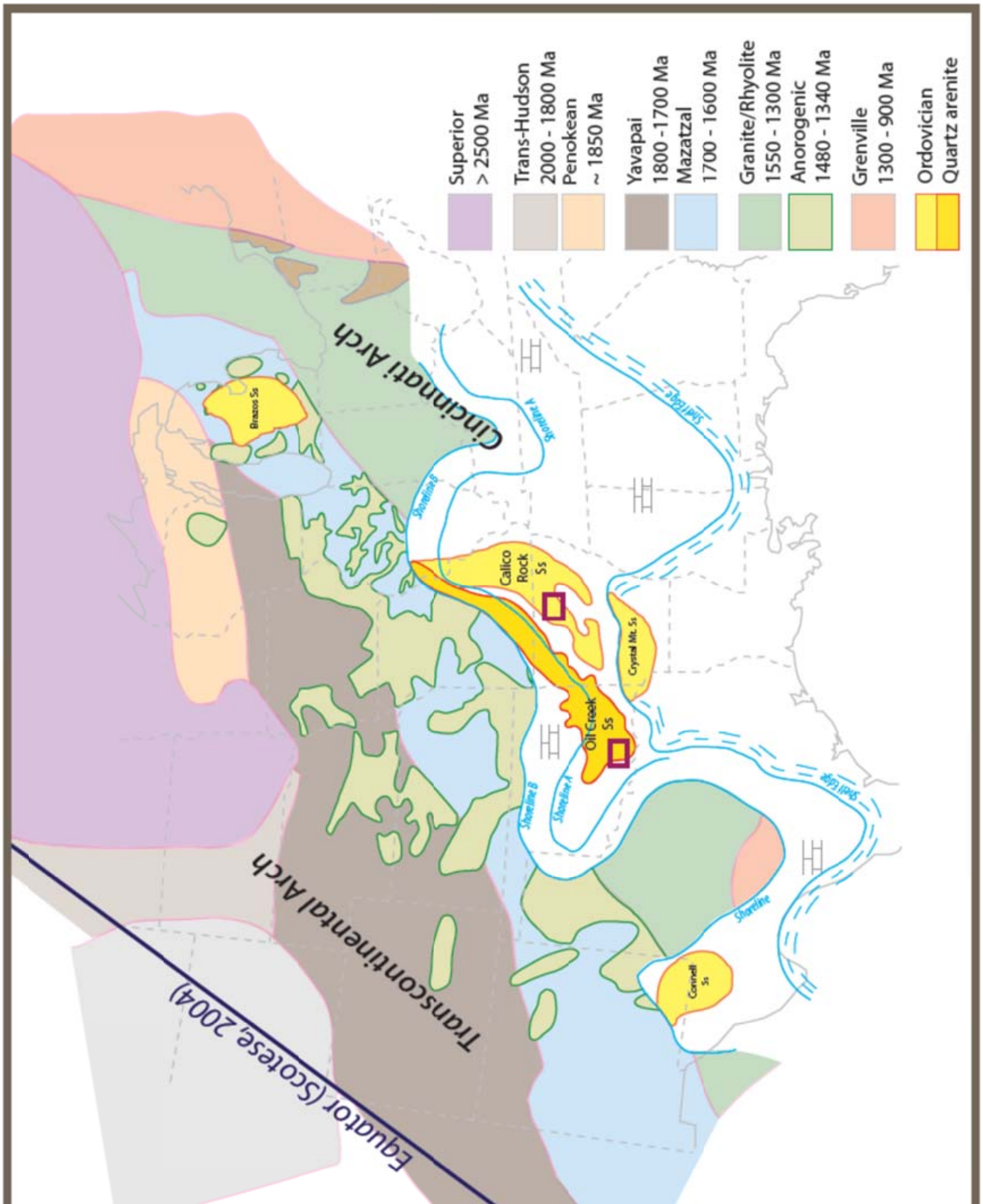

Superior
> 2500 Ma
Trans-Hudson
2000 - 1800 Ma
Penokean
~ 1850 Ma
Yavapai
1800 -1700 Ma
Mazatzal
1700 - 1600 Ma
Granite/Rhyolite
1550 - 1300 Ma
Anorogenic
1480 - 1340 Ma
Grenville
1300 - 900 Ma
Ordovician
Quartz arenite
Cincinnati Arch
Transcontinental Arch
Equator (Scotese, 2004)
Brazos Ss
Calico Rock Ss
Crystal Mt. Ss
Oil Creek Ss
Shoreline B
Shoreline A
Shelf Edge
Shoreline

Figure 2

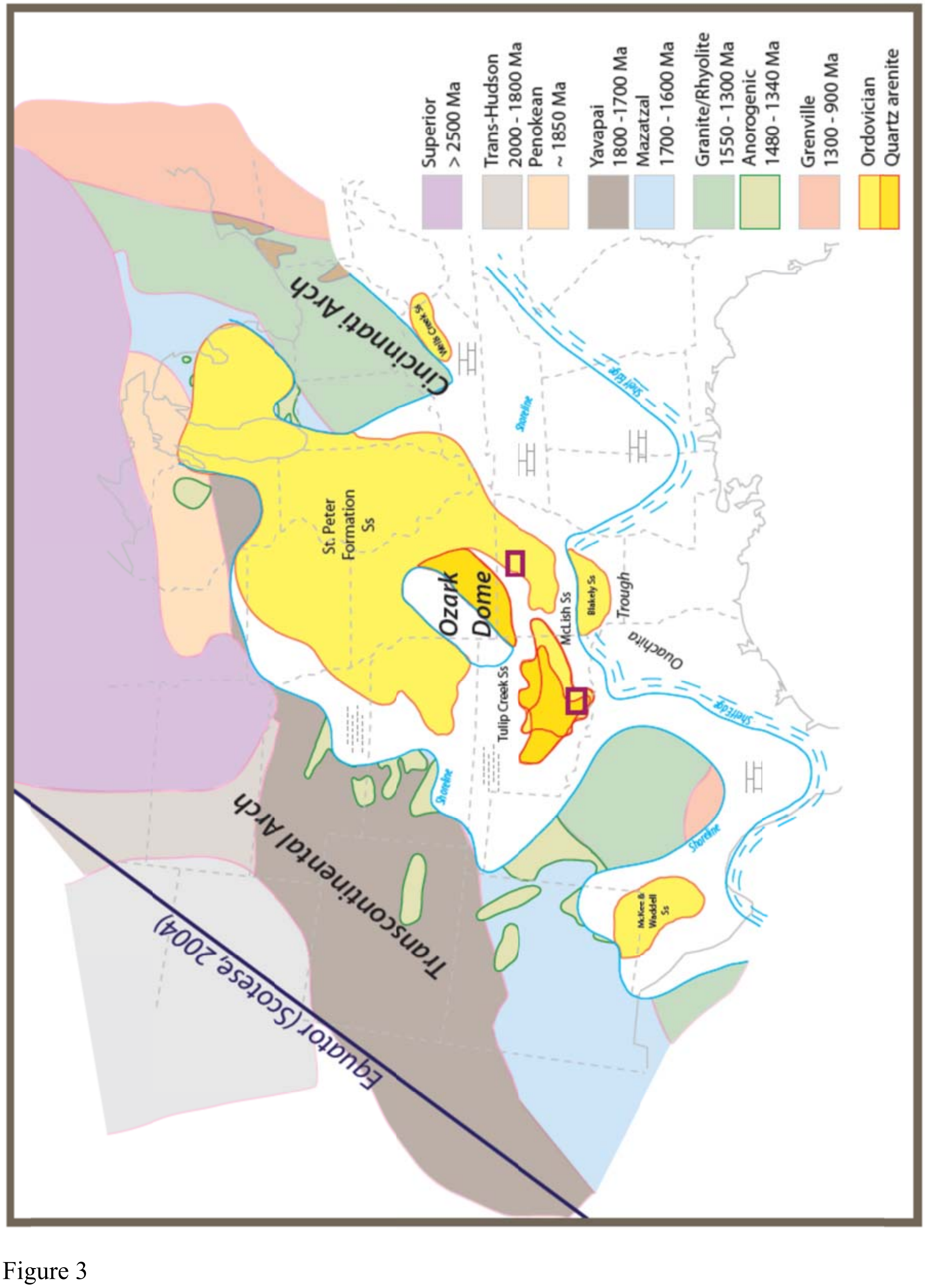

Superior
> 2500 Ma
Trans-Hudson
2000 - 1800 Ma
Penokean
~ 1850 Ma
Yavapai
1800 -1700 Ma
Mazatzal
1700 - 1600 Ma
Granite/Rhyolite
1550 - 1300 Ma
Anorogenic
1480 - 1340 Ma
Grenville
1300 - 900 Ma
Ordovician
Quartz arenite
Cincinnati Arch
St. Peter Formation Ss
Ozark Dome
McLish Ss
Blakely Ss
Trough
Ouachita
Tulip Creek Ss
Shoreline
Shelf Edge
McKee & Waddell Ss
Transcontinental Arch
Equator (Scotese, 2004)

Figure 3

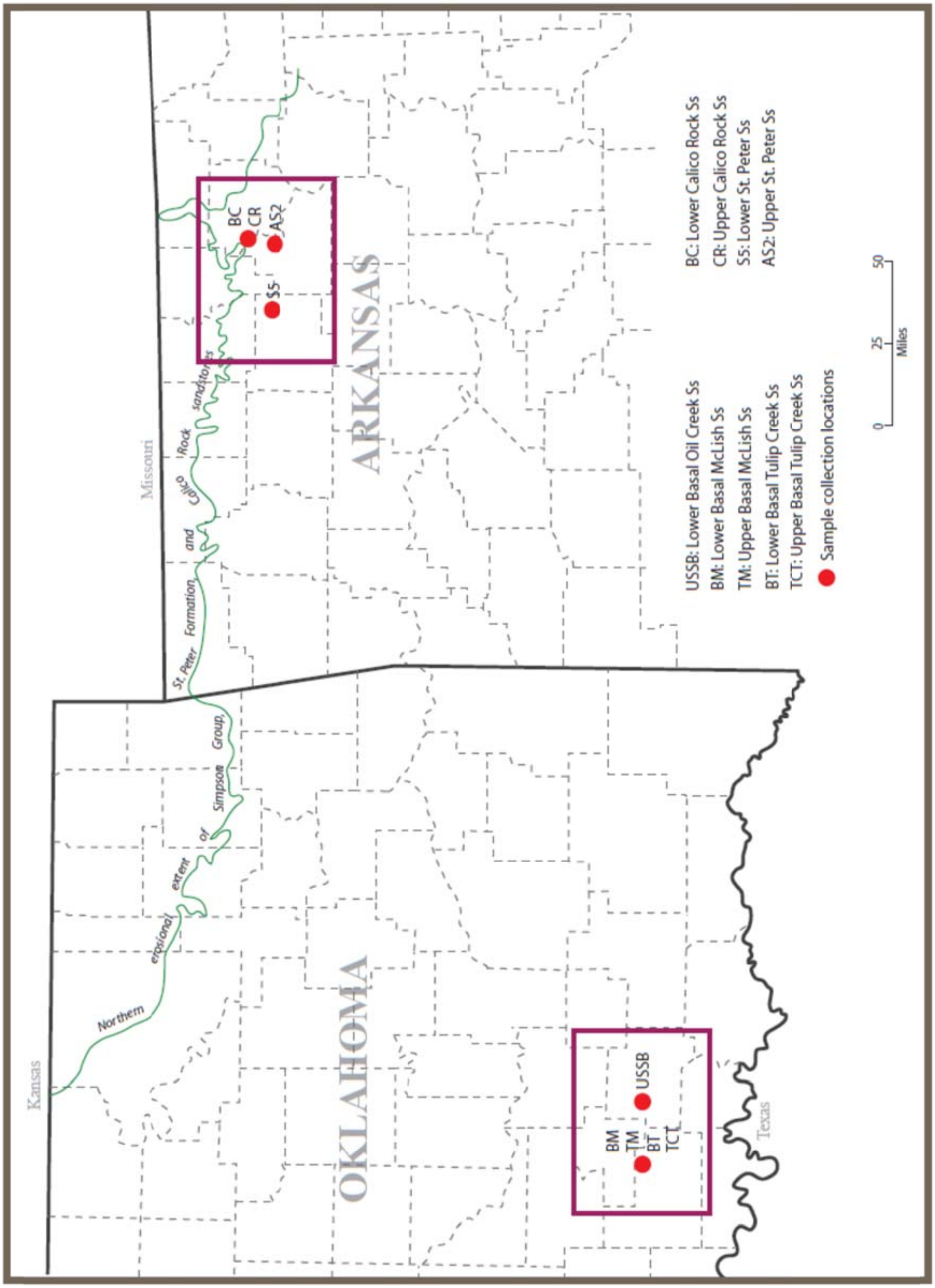

Missouri
Kansas
Texas
ARKANSAS
OKLAHOMA
Northern erosional extent of Simpson Group, St. Peter Formation and Calico Rock sandstones
BC
CR
AS2
S5
USSB
BM
TM
BT
TCT
BC: Lower Calico Rock Ss
CR: Upper Calico Rock Ss
S5: Lower St. Peter Ss
AS2: Upper St. Peter Ss
USSB: Lower Basal Oil Creek Ss
BM: Lower Basal McLish Ss
TM: Upper Basal McLish Ss
BT: Lower Basal Tulip Creek Ss
TCT: Upper Basal Tulip Creek Ss
Sample collection locations
0
25
50
Miles

Figure 4

Figure 5

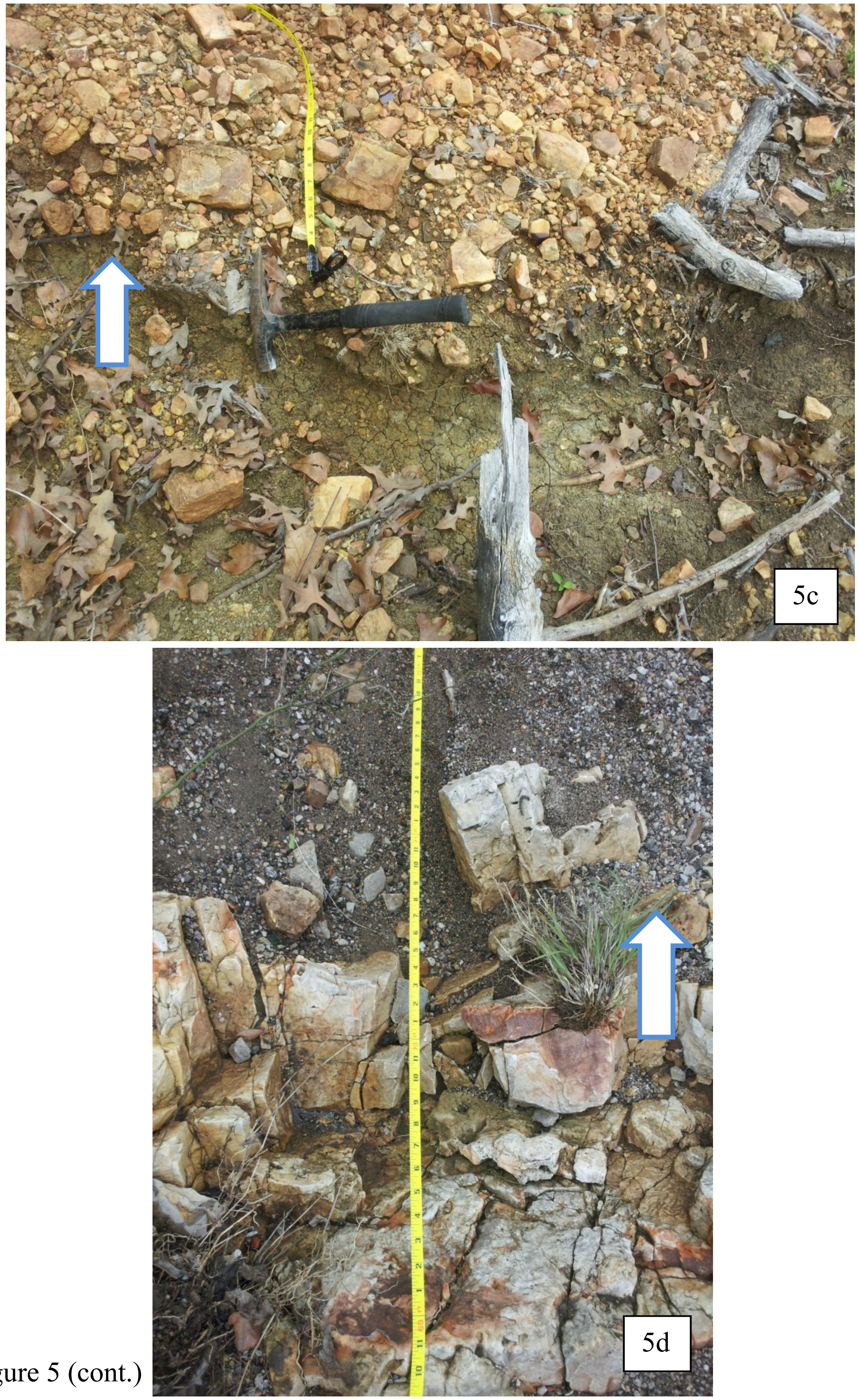


Figure 5 (cont.)

Figure 5 (cont.)

Figure 5 (cont.)

Figure 5 (cont.)

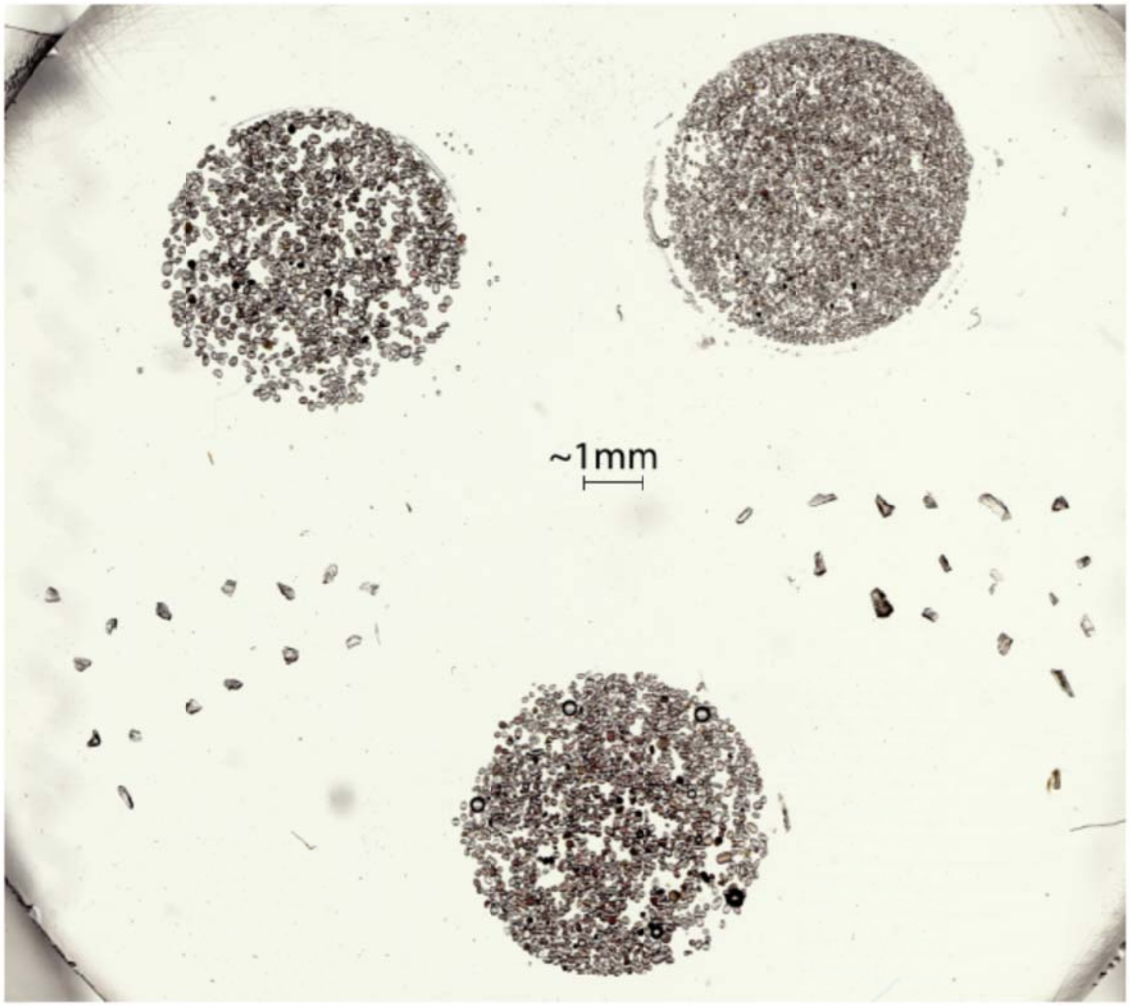
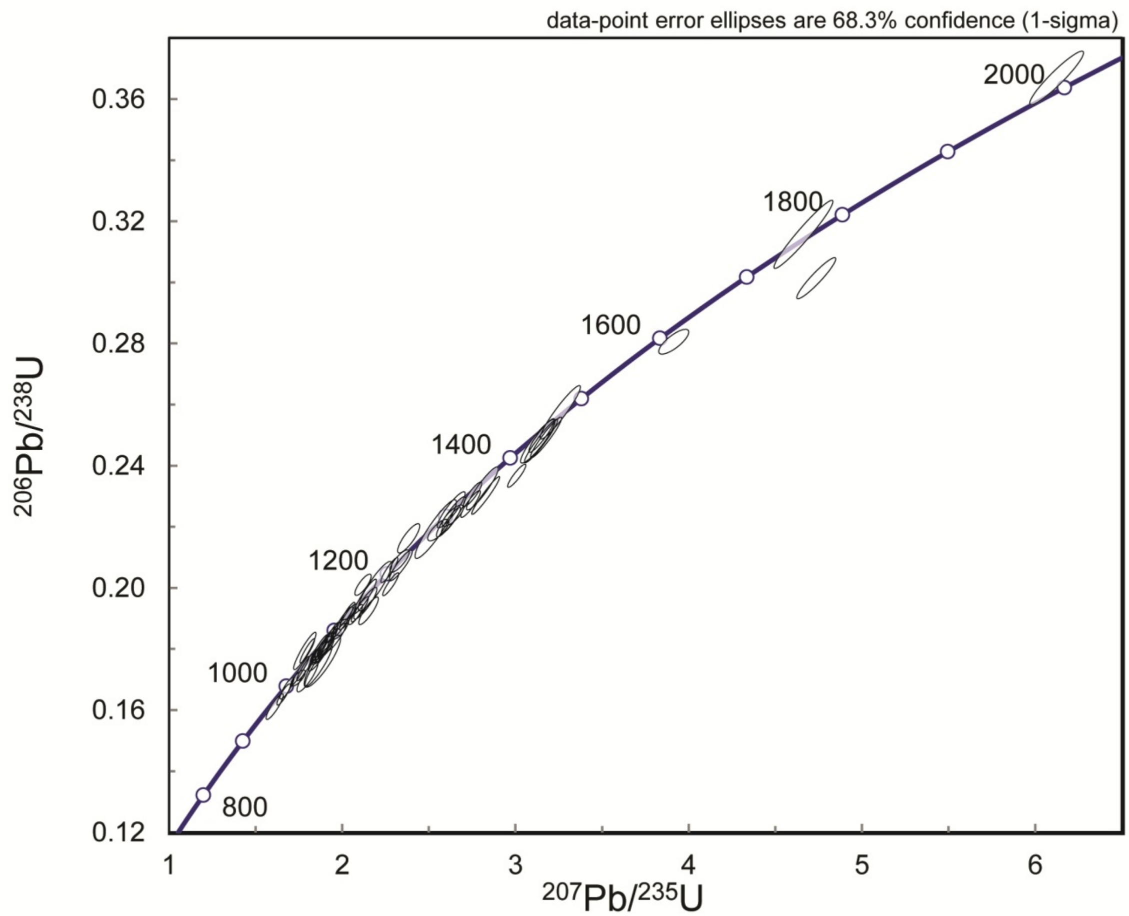
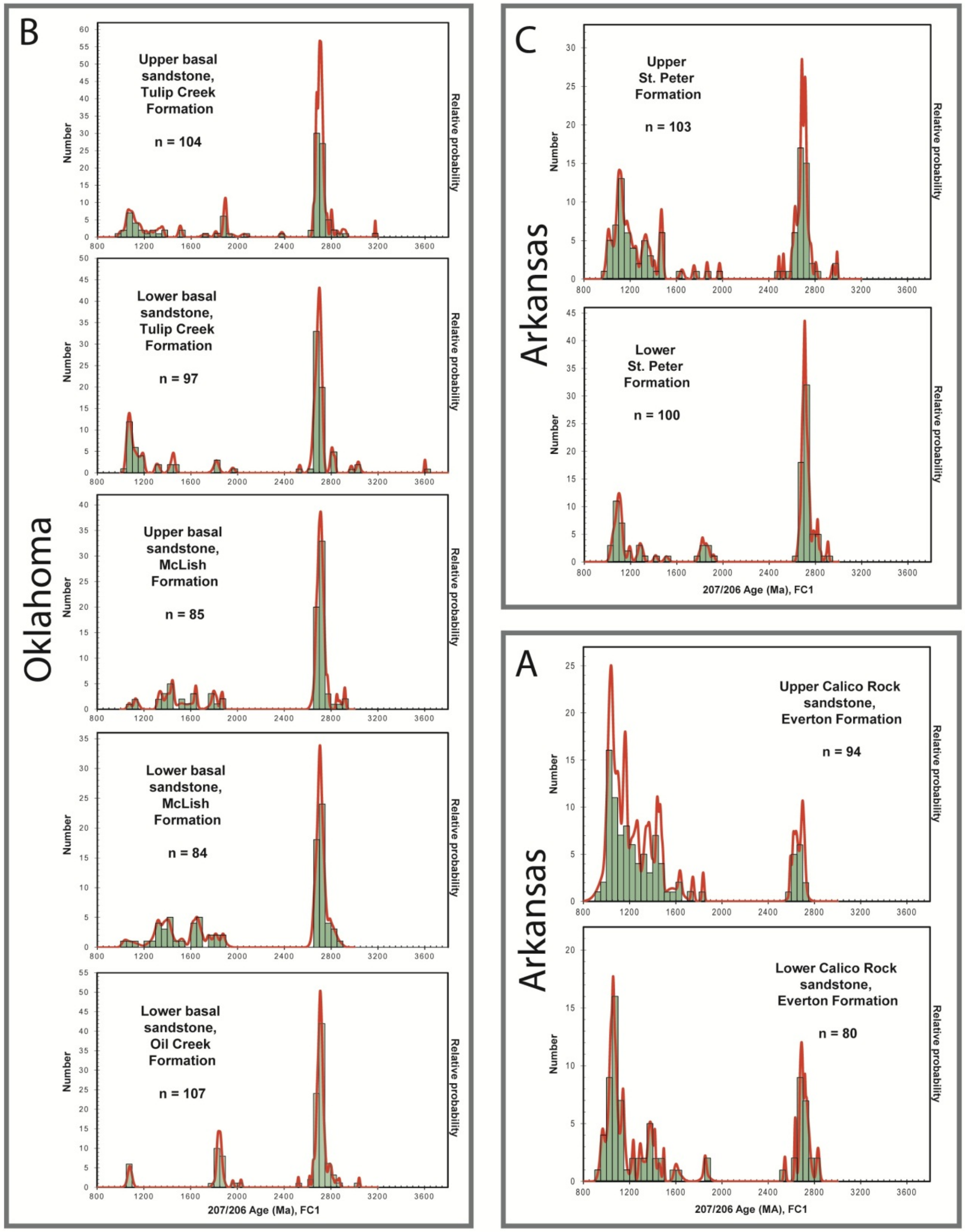


Figure 6



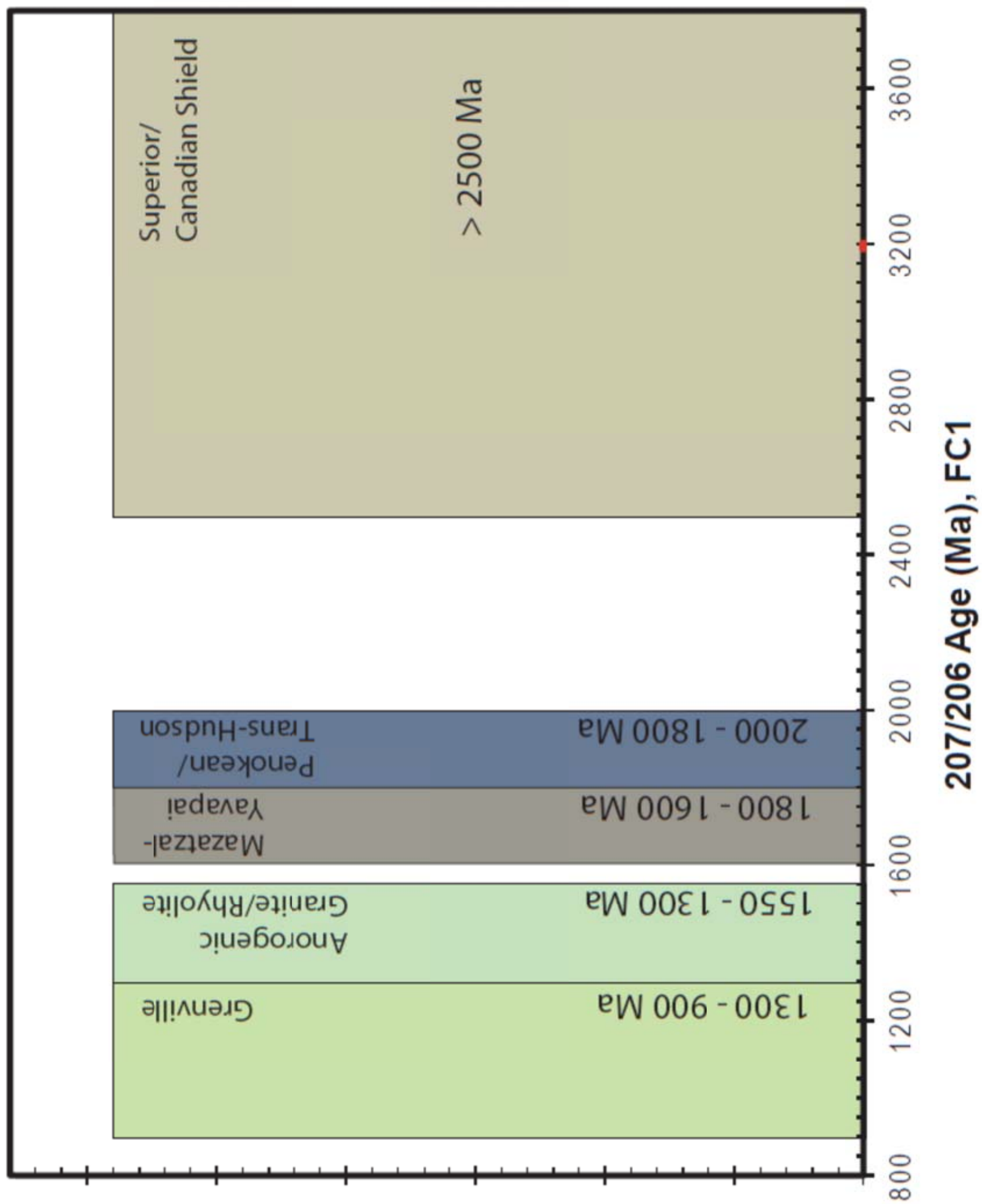
data-point error ellipses are 68.3% confidence (1-sigma)
0.36
0.32
0.28
0.24
0.20
0.16
0.12
206Pb/238U
2000
1800
1600
1400
1200
1000
800
1
2
3
4
5
6
207Pb/235U

Figure 7



B
Oklahoma
Upper basal sandstone, Tulip Creek Formation
n = 104
Lower basal sandstone, Tulip Creek Formation
n = 97
Upper basal sandstone, McLish Formation
n = 85
Lower basal sandstone, McLish Formation
n = 84
Lower basal sandstone, Oil Creek Formation
n = 107
Number
Relative probability
207/206 Age (Ma), FC1
C
Arkansas
Upper St. Peter Formation
n = 103
Lower St. Peter Formation
n = 100
207/206 Age (Ma), FC1
A
Arkansas
Upper Calico Rock sandstone, Everton Formation
n = 94
Lower Calico Rock sandstone, Everton Formation
n = 80
207/206 Age (MA), FC1

Figure 8



Superior/
Canadian Shield
> 2500 Ma
Grenville
1300 - 900 Ma
Anorogenic
Granite/Rhyolite
1550 - 1300 Ma
Mazatzal-
Yavapai
1800 - 1600 Ma
Penokean/
Trans-Hudson
2000 - 1800 Ma
800
1200
1600
2000
2400
2800
3200
3600
207/206 Age (Ma), FC1

Figure 9

APPENDIX C

TABLES

SAMPLE AGE DISTRIBUTION

PROVINCE	Grenville (900 Ma - 1300 Ma)		Granite-Rhyolite/Anorogenic (1300 Ma - 1550 Ma)		Yavapai-Mazatzal (1600 Ma - 1800 Ma)		Trans-Hudson/Penokean (1800 Ma - 2000 Ma)		Superior (> 2500 Ma)		Other	Total
SAMPLE	n	%	n	%	n	%	n	%	n	%	n	n
BC - Lower Calico Rock	42	0.53	11	0.14	2	0.03	2	0.03	23	0.29	0	80
CR - Upper Calico Rock	55	0.59	20	0.21	3	0.03	1	0.01	14	0.15	1	94
USSB - Lower Basal Oil Creek	6	0.06	0	0.00	1	0.01	19	0.18	80	0.75	1	107
BM - Lower Basal McLish	5	0.06	14	0.17	11	0.13	4	0.05	50	0.60	0	84
TM - Upper Basal McLish	3	0.04	12	0.14	6	0.07	3	0.04	60	0.71	1	85
SS - Lower St. Peter	26	0.26	3	0.03	1	0.01	7	0.07	63	0.63	0	100
AS2 - Upper St. Peter	38	0.37	15	0.15	2	0.02	2	0.02	45	0.44	1	103
BT - Lower Basal Tulip Creek	23	0.24	6	0.06	0	0.00	4	0.04	64	0.66	0	97
TCT - Upper Basal Tulip Creek	19	0.18	5	0.05	1	0.01	8	0.08	69	0.66	2	104

Table 1

OVERLAP

Mean: 0.665

Median: 0.671

$1\text{-}\sigma$: 0.112

BC - Lower Calico Rock	BC - Lower Calico Rock								
CR - Upper Calico Rock	0.774	CR - Upper Calico Rock							
S5 - Lower St. Peter	0.763	0.612	S5 - Lower St. Peter						
AS2 - Upper St. Peter	0.764	0.734	0.661	AS2 - Upper St. Peter					
USSB - Lower Oil Creek	0.538	0.334	0.640	0.483	USSB - Lower Oil Creek				
BM - Lower McLish	0.836	0.797	0.845	0.753	0.554	BM - Lower McLish			
TM - Upper McLish	0.730	0.718	0.720	0.674	0.542	0.870	TM - Upper McLish		
BT - Lower Tulip Creek	0.650	0.535	0.675	0.716	0.624	0.645	0.591	BT - Lower Tulip Creek	
TCT - Upper Tulip Creek	0.684	0.609	0.752	0.667	0.573	0.786	0.552	0.557	TCT - Upper Tulip Creek

Table 2

SIMILARITY

Mean: 0.724

Median: 0.743

1-σ: 0.102

	BC - Lower Calico Rock	CR - Upper Calico Rock	S5 - Lower St. Peter	AS2 - Upper St. Peter	USSB - Lower Oil Creek	BM - Lower McLish	TM - Upper McLish	BT - Lower Tulip Creek	TCT - Upper Tulip Creek
BC - Lower Calico Rock	BC -Lower Calico Rock								
CR - Upper Calico Rock	0.825	CR - Upper Calico Rock							
S5 - Lower St. Peter	0.739	0.585	S5 - Lower St. Peter						
AS2 - Upper St. Peter	0.795	0.812	0.747	AS2 - Upper St. Peter					
USSB - Lower Oil Creek	0.572	0.372	0.826	0.607	USSB - Lower Oil Creek				
BM - Lower McLish	0.719	0.624	0.797	0.740	0.736	BM - Lower McLish			
TM - Upper McLish	0.652	0.535	0.782	0.698	0.768	0.881	TM - Upper McLish		
BT - Lower Tulip Creek	0.710	0.626	0.820	0.781	0.759	0.727	0.726	BT - Lower Tulip Creek	
TCT - Upper Tulip Creek	0.719	0.601	0.862	0.765	0.776	0.804	0.780	0.790	TCT - Upper Tulip Creek

Table 3

K-S STATISTIC P-VALUES

BC - Lower Calloo Rock	BC - Lower Calloo Rock								
CR - Upper Calloo Rock	0.169	CR - Upper Calloo Rock							
S5 - Lower St. Peter	0.000	0.000	S5 - Lower St. Peter						
AS2 - Upper St. Peter	0.015	0.000	0.001	AS2 - Upper St. Peter					
USSB - Lower Oil Creek	0.000	0.000	0.006	0.000	USSB - Lower Oil Creek				
BM - Lower McLish	0.000	0.000	0.057	0.000	0.000	BM - Lower McLish			
TM - Upper McLish	0.000	0.000	0.017	0.000	0.065	0.516	TM - Upper McLish		
BT - Lower Tulip Creek	0.000	0.000	0.381	0.003	0.005	0.057	0.039	BT - Lower Tulip Creek	
TCT - Upper Tulip Creek	0.000	0.000	0.743	0.000	0.057	0.375	0.273	0.851	TCT - Upper Tulip Creek

Table 4

APPENDIX D

Sample Collection Locations

Sample	Latitude	Longitude	County	State	Description
BC	N 36.1162°	W 92.1432°	Izard	Arkansas	Near Hwy 5 bridge, north side of White River
CR	N 36.1180°	W 92.1493°	Izard	Arkansas	Empty lot off Chessman Ferry Road, west of Calico Rock, AR
USSB	N 34.4693°	W 96.9300°	Johnston	Oklahoma	US Silica Mill Creek Quarry
BM	N 34.3614°	W 97.1442°	Carter	Oklahoma	Outcrop in bar ditch, east side of road, Hwy 77, north of Springer, OK
TM	N 34.3612°	W 97.1444°	Carter	Oklahoma	Outcrop in bar ditch, east side of road, Hwy 77, north of Springer, OK
BT	N 34.3601°	W 97.1456°	Carter	Oklahoma	Outcrop in bar ditch, west side of road, Hwy 77, north of Springer, OK
TCT	N 34.3597°	W 97.1459°	Carter	Oklahoma	Outcrop in bar ditch, west side of road, Hwy 77, north of Springer, OK
S5	N 35.9795°	W 92.4811°	Searcy	Arkansas	Outcrop, east side of road, Hwy 14, just north of Big Creek bridge
AS2	N 35.9345°	W 92.1171°	Stone	Arkansas	Outcrop, east side of road, Hwy 14/5, just south of Allison, AR

APPENDIX E

Data Tables for Sample BC –

Lower Calico Rock Sandstone,

Everton Formation

Sample BC - Lower Calico Rock Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
BC_19b	11.315	4.38%	2.170	4.32%	0.178	0.43%	2549	40	2444	87	2635	7	7.3%
BC_19	1.680	4.39%	6.112	4.33%	0.074	0.45%	1001	28	977	39	1054	9	7.4%
BC_6	1.660	4.39%	6.130	4.32%	0.074	0.45%	993	27	974	39	1036	9	6.0%
BC_103	3.640	3.67%	3.798	1.97%	0.100	1.67%	1558	29	1507	26	1629	31	7.5%
BC_41	1.970	3.65%	5.451	1.93%	0.078	1.67%	1105	24	1086	19	1143	33	5.0%
BC_40	12.333	3.80%	2.050	1.50%	0.183	1.88%	2630	35	2561	32	2683	31	4.5%
BC_58	2.042	3.81%	5.318	1.53%	0.079	1.89%	1130	26	1111	16	1166	37	4.7%
BC_20	1.623	3.80%	6.168	1.50%	0.073	1.89%	979	24	969	13	1002	38	3.3%
BC_36	4.990	3.85%	3.144	1.60%	0.114	1.89%	1818	32	1780	25	1861	34	4.3%
BC_235	1.692	1.38%	6.101	1.23%	0.075	0.39%	1006	9	978	11	1065	8	8.2%
BC_118	1.622	1.47%	6.277	1.24%	0.074	0.53%	979	9	953	11	1037	11	8.1%
BC_145	11.125	1.37%	2.204	1.21%	0.178	0.38%	2534	13	2412	24	2633	6	8.4%
BC_151	1.593	1.57%	6.387	1.33%	0.074	0.57%	967	10	938	12	1036	12	9.5%
BC_115	2.118	1.38%	5.308	1.22%	0.082	0.41%	1155	9	1113	12	1234	8	9.8%
BC_101	1.731	1.62%	6.044	1.32%	0.076	0.66%	1020	10	987	12	1092	13	9.6%
BC_85	1.763	1.39%	5.901	1.23%	0.075	0.39%	1032	9	1009	12	1080	8	6.6%
BC_266	12.336	1.20%	2.091	1.11%	0.187	0.28%	2630	11	2520	23	2717	5	7.2%
BC_336	3.152	1.22%	4.086	1.11%	0.093	0.34%	1445	9	1411	14	1496	6	5.7%
BC_334	1.727	1.14%	5.956	1.05%	0.075	0.29%	1019	7	1001	10	1058	6	5.4%
BC_307	1.910	1.18%	5.619	1.05%	0.078	0.36%	1085	8	1056	10	1143	7	7.6%
BC_298	2.727	1.43%	4.535	1.34%	0.090	0.32%	1336	11	1285	16	1419	6	9.5%
BC_177	11.782	1.27%	2.133	1.14%	0.182	0.39%	2587	12	2479	23	2673	6	7.3%
BC_383	1.623	4.25%	6.256	4.03%	0.074	0.90%	979	26	956	36	1032	18	7.4%
BC_645	12.776	4.07%	2.059	3.91%	0.191	0.65%	2663	38	2551	82	2749	11	7.2%
BC_633	14.141	4.05%	1.956	3.89%	0.201	0.65%	2759	38	2662	84	2831	11	6.0%
BC_576	2.610	4.11%	4.612	3.94%	0.087	0.73%	1304	30	1265	45	1367	14	7.5%
BC_379	1.716	4.15%	6.030	3.93%	0.075	0.90%	1014	26	989	36	1069	18	7.5%
BC_322	2.417	4.18%	4.862	3.97%	0.085	0.83%	1248	30	1206	44	1321	16	8.7%
BC_275	2.717	4.14%	4.482	3.98%	0.088	0.70%	1333	30	1298	47	1389	13	6.5%
BC_134	12.213	4.09%	2.079	3.94%	0.184	0.65%	2621	38	2532	82	2690	11	5.9%
BC_410	2.326	1.90%	4.973	1.64%	0.084	0.59%	1220	13	1181	18	1290	12	8.4%
BC_602	10.427	1.74%	2.230	1.51%	0.169	0.51%	2473	16	2388	30	2544	9	6.1%
BC_715	12.251	1.89%	2.063	1.67%	0.183	0.54%	2624	18	2548	35	2683	9	5.0%
BC_777	1.736	2.71%	6.022	2.16%	0.076	1.20%	1022	17	990	20	1090	24	9.2%
BC_747	1.608	2.26%	6.353	1.74%	0.074	1.05%	973	14	942	15	1044	21	9.8%
BC_710	2.670	1.96%	4.570	1.67%	0.088	0.67%	1320	14	1276	19	1393	13	8.4%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
BC_636	12.020	1.87%	2.100	1.63%	0.183	0.55%	2606	17	2511	34	2681	9	6.3%
BC_597	12.687	2.03%	2.050	1.82%	0.189	0.55%	2657	19	2561	38	2731	9	6.2%
BC_714	1.931	2.89%	5.509	2.35%	0.077	1.04%	1092	19	1075	23	1126	21	4.5%
BC_675	1.640	2.76%	6.157	2.23%	0.073	0.97%	986	17	970	20	1021	20	4.9%
BC_845	3.546	2.67%	3.838	2.19%	0.099	0.88%	1538	21	1493	29	1600	16	6.7%
BC_872	1.991	2.83%	5.385	2.36%	0.078	0.91%	1112	19	1098	24	1141	18	3.8%
BC_891	12.628	2.72%	2.049	2.25%	0.188	0.87%	2652	25	2562	47	2722	14	5.9%
BC_896	13.235	2.69%	1.961	2.21%	0.188	0.87%	2697	25	2656	48	2727	14	2.6%
BC_741	1.533	2.68%	6.423	2.18%	0.071	0.92%	944	16	933	19	970	19	3.8%
BC_765	1.674	2.99%	6.051	2.47%	0.073	0.99%	999	19	986	23	1027	20	4.0%
BC_520	13.546	2.99%	1.965	2.49%	0.193	0.95%	2718	28	2652	54	2769	16	4.2%
BC_618	2.611	3.08%	4.561	2.57%	0.086	1.02%	1304	22	1278	30	1347	19	5.1%
BC_817	12.235	3.04%	2.066	2.55%	0.183	0.96%	2623	28	2545	53	2683	16	5.1%
BC_857	14.477	2.98%	1.910	2.48%	0.201	0.96%	2782	28	2714	55	2831	16	4.1%
BC_193	1.744	1.45%	5.924	1.07%	0.075	0.62%	1025	9	1005	10	1067	12	5.8%
BC_209	2.544	1.54%	4.554	1.19%	0.084	0.63%	1285	11	1280	14	1294	12	1.1%
BC_232	2.987	1.69%	4.224	1.36%	0.092	0.66%	1404	13	1370	17	1457	12	6.0%
BC_277	12.787	1.56%	2.033	1.23%	0.189	0.60%	2664	15	2579	26	2730	10	5.5%
BC_267	1.708	1.61%	6.001	1.18%	0.074	0.74%	1011	10	993	11	1051	15	5.4%
BC_353	12.496	1.57%	2.029	1.26%	0.184	0.58%	2642	15	2583	27	2688	10	3.9%
BC_350	1.461	1.53%	6.716	1.14%	0.071	0.66%	914	9	895	10	962	14	7.0%
BC_465	1.537	1.91%	6.329	1.37%	0.071	0.97%	945	12	946	12	945	20	-0.1%
BC_469	1.812	1.77%	5.749	1.44%	0.076	0.68%	1050	12	1034	14	1083	14	4.6%
BC_100	2.220	2.26%	5.042	2.03%	0.081	0.67%	1187	16	1166	22	1226	13	4.9%
BC_90	1.725	2.21%	5.951	2.01%	0.074	0.60%	1018	14	1001	19	1054	12	5.0%
BC_89	1.549	2.23%	6.366	1.98%	0.072	0.71%	950	14	941	17	972	14	3.3%
BC_17	4.854	2.21%	3.220	2.02%	0.113	0.59%	1794	18	1744	31	1854	11	5.9%
BC_38	2.689	2.23%	4.480	2.03%	0.087	0.59%	1325	16	1299	24	1369	11	5.1%
BC_93	1.597	2.35%	6.302	2.12%	0.073	0.70%	969	15	949	19	1014	14	6.4%
BC_109	11.820	2.25%	2.153	2.07%	0.185	0.56%	2590	21	2459	42	2695	9	8.7%
BC_471	13.861	1.88%	1.901	1.35%	0.191	0.81%	2740	18	2725	30	2752	13	1.0%
BC_436	2.782	1.87%	4.367	1.31%	0.088	0.83%	1351	14	1329	16	1385	16	4.0%
BC_374	1.799	2.08%	5.718	1.45%	0.075	1.00%	1045	13	1039	14	1058	20	1.8%
BC_369	1.604	2.18%	6.228	1.53%	0.072	1.08%	972	14	960	14	999	22	3.9%
BC_343	1.715	1.88%	5.978	1.30%	0.074	0.87%	1014	12	997	12	1051	18	5.1%
BC_244	1.816	1.84%	5.757	1.27%	0.076	0.83%	1051	12	1033	12	1090	17	5.3%
BC_188	3.039	1.85%	4.074	1.28%	0.090	0.84%	1417	14	1415	16	1421	16	0.4%
BC_1052	1.973	2.20%	5.394	1.75%	0.077	0.97%	1106	15	1096	18	1126	19	2.6%
BC_1156	12.780	1.74%	2.001	1.42%	0.185	0.63%	2664	16	2613	30	2702	10	3.3%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
BC_1165	2.126	2.17%	5.065	1.86%	0.078	0.73%	1157	15	1161	20	1150	15	-1.0%
BC_1155	12.681	2.09%	2.011	1.81%	0.185	0.67%	2656	19	2602	39	2698	11	3.6%
BC_1093	1.762	1.93%	5.898	1.59%	0.075	0.74%	1032	12	1010	15	1079	15	6.4%
BC_829	1.996	1.99%	5.390	1.54%	0.078	0.90%	1114	13	1097	16	1147	18	4.4%
BC_551	1.820	1.79%	5.646	1.42%	0.075	0.71%	1053	12	1051	14	1055	14	0.4%
							>10% Discordant						
BC_57	3.724	5.82%	7.024	5.75%	0.190	0.62%	1576	46	858	46	2739	10	68.7%
BC_10	1.778	4.41%	6.040	4.33%	0.078	0.53%	1037	28	988	40	1143	10	13.6%
BC_127	1.741	3.76%	6.262	2.12%	0.079	1.68%	1024	24	955	19	1174	33	18.6%
BC_126	2.858	3.64%	4.560	1.91%	0.095	1.67%	1371	27	1278	22	1518	31	15.8%
BC_94	1.458	3.63%	6.966	1.92%	0.074	1.66%	913	22	865	15	1032	33	16.2%
BC_22	1.527	3.99%	8.400	1.86%	0.093	1.92%	941	24	725	13	1488	36	51.3%
BC_210	8.418	2.15%	2.950	2.07%	0.180	0.38%	2277	19	1882	34	2654	6	29.1%
BC_108	1.615	1.39%	6.356	1.22%	0.074	0.42%	976	9	942	11	1054	8	10.6%
BC_56	9.163	1.89%	2.677	1.79%	0.178	0.36%	2354	17	2046	31	2633	6	22.3%
BC_186	4.949	1.23%	6.105	1.15%	0.219	0.29%	1811	10	978	10	2974	5	67.1%
BC_226	0.921	1.36%	64.066	1.09%	0.428	0.60%	663	7	100	1	4010	9	97.5%
BC_310	0.973	3.39%	17.379	3.22%	0.123	0.82%	690	17	361	11	1996	14	81.9%
BC_240	2.171	1.30%	5.403	1.11%	0.085	0.48%	1172	9	1095	11	1317	9	16.9%
BC_362	1.502	4.18%	8.143	4.02%	0.089	0.69%	931	25	747	28	1398	13	46.6%
BC_417	0.443	4.55%	40.235	4.25%	0.129	1.16%	372	14	158	7	2086	20	92.4%
BC_507	10.936	1.89%	2.373	1.63%	0.188	0.60%	2518	17	2267	31	2727	10	16.9%
BC_759	3.235	6.49%	7.620	6.42%	0.179	0.55%	1466	49	795	48	2642	9	69.9%
BC_609	1.874	2.77%	5.912	2.28%	0.080	0.93%	1072	18	1007	21	1205	18	16.4%
BC_853	1.553	2.82%	6.748	2.36%	0.076	0.89%	951	17	891	20	1095	18	18.6%
BC_680	4.350	2.68%	10.769	2.22%	0.340	0.86%	1703	22	572	12	3662	13	84.4%
BC_758	2.841	3.57%	9.759	3.15%	0.201	0.98%	1366	26	629	19	2835	16	77.8%
BC_689	0.591	4.55%	29.544	4.09%	0.127	1.29%	471	17	215	9	2051	23	89.5%
BC_527	1.285	3.06%	9.367	2.55%	0.087	0.99%	839	17	654	16	1367	19	52.2%
BC_595	1.267	3.14%	8.451	2.63%	0.078	1.02%	831	18	721	18	1139	20	36.7%
BC_657	11.267	3.09%	2.231	2.61%	0.182	0.97%	2546	28	2388	52	2674	16	10.7%
BC_433	2.051	1.54%	21.312	1.23%	0.317	0.57%	1133	10	296	4	3556	9	91.7%
BC_43	2.875	2.31%	17.586	2.13%	0.367	0.59%	1375	17	357	7	3778	9	90.6%
BC_80	1.456	2.28%	7.893	2.07%	0.083	0.64%	912	14	769	15	1277	12	39.8%
BC_156	5.307	3.47%	4.866	3.35%	0.187	0.59%	1870	29	1205	37	2719	10	55.7%
BC_536	6.764	2.11%	3.701	1.65%	0.182	0.81%	2081	18	1542	23	2667	13	42.2%
BC_368	0.729	3.34%	62.444	2.06%	0.330	2.08%	556	14	102	2	3618	32	97.2%
BC_283	0.536	5.19%	31.314	4.66%	0.122	1.79%	436	18	203	9	1981	32	89.8%
BC_1108	10.864	2.01%	2.464	1.71%	0.194	0.68%	2512	19	2196	32	2778	11	21.0%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
BC_932	1.391	1.86%	9.887	1.46%	0.100	0.79%	885	11	621	9	1619	15	61.6%
BC_534	1.861	1.83%	6.504	1.52%	0.088	0.65%	1067	12	922	13	1378	12	33.1%

APPENDIX F

Data Tables for Sample CR –

Upper Calico Rock Sandstone,

Everton Formation

Sample CR - Upper Calico Rock Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
CR_134	2.401	2.27%	4.710	2.03%	0.082	1.03%	1243	16	1241	23	1246	20	0.4%
CR_84	12.344	3.67%	2.051	3.54%	0.184	0.89%	2631	34	2560	74	2686	15	4.7%
CR_103	2.027	1.64%	5.331	1.43%	0.078	0.80%	1125	11	1108	15	1156	16	4.2%
CR_57	4.470	1.38%	3.298	1.21%	0.107	0.61%	1725	11	1707	18	1747	11	2.3%
CR_53	4.962	1.30%	3.121	1.16%	0.112	0.52%	1813	11	1792	18	1837	9	2.4%
CR_36	2.191	2.03%	5.167	1.80%	0.082	0.94%	1178	14	1141	19	1248	18	8.6%
CR_26	1.727	1.45%	5.870	1.23%	0.074	0.75%	1019	9	1014	12	1028	15	1.4%
CR_9	13.566	2.10%	1.894	1.99%	0.186	0.63%	2720	20	2732	44	2711	10	-0.8%
CR_1	2.213	1.84%	5.090	1.56%	0.082	0.98%	1185	13	1156	17	1238	19	6.6%
CR_447	3.076	1.34%	4.126	1.21%	0.092	0.51%	1427	10	1399	15	1469	10	4.8%
CR_422	1.701	1.38%	5.990	1.24%	0.074	0.55%	1009	9	995	11	1039	11	4.2%
CR_425	3.067	1.50%	4.080	1.35%	0.091	0.62%	1425	11	1413	17	1442	12	2.0%
CR_301	2.242	1.65%	4.957	1.47%	0.081	0.75%	1194	12	1185	16	1212	15	2.2%
CR_251	2.055	1.58%	5.288	1.40%	0.079	0.72%	1134	11	1116	14	1167	14	4.3%
CR_244	2.809	1.77%	4.305	1.59%	0.088	0.78%	1358	13	1347	19	1376	15	2.1%
CR_166	1.847	1.87%	5.751	1.63%	0.077	0.94%	1062	12	1033	16	1122	19	7.9%
CR_171	2.532	1.52%	4.751	1.34%	0.087	0.69%	1281	11	1231	15	1366	13	9.9%
CR_123	2.050	1.44%	5.290	1.32%	0.079	0.54%	1132	10	1116	13	1163	11	4.1%
CR_489	1.726	2.20%	5.954	1.98%	0.075	1.01%	1018	14	1001	18	1056	20	5.3%
CR_513	2.326	2.07%	4.914	1.89%	0.083	0.85%	1220	15	1194	21	1267	16	5.7%
CR_516	1.851	1.88%	5.687	1.72%	0.076	0.77%	1064	12	1044	17	1105	15	5.5%
CR_519	1.804	1.91%	5.800	1.75%	0.076	0.76%	1047	12	1025	17	1093	15	6.1%
CR_551	1.649	1.63%	6.051	1.52%	0.072	0.56%	989	10	986	14	997	11	1.1%
CR_525	1.633	2.04%	6.184	1.83%	0.073	0.92%	983	13	966	16	1020	18	5.3%
CR_393	2.046	1.74%	5.307	1.65%	0.079	0.54%	1131	12	1113	17	1166	11	4.6%
CR_492	10.482	1.72%	2.283	1.65%	0.174	0.44%	2478	16	2342	32	2593	7	9.7%
CR_468	1.990	1.66%	5.404	1.54%	0.078	0.62%	1112	11	1094	15	1147	12	4.6%
CR_502	1.638	3.16%	6.195	0.87%	0.074	2.42%	985	20	965	8	1031	48	6.4%
CR_483	12.895	3.12%	1.969	0.89%	0.184	2.35%	2672	29	2648	19	2690	38	1.6%
CR_538	11.532	3.12%	2.143	0.89%	0.179	2.35%	2567	29	2469	18	2646	38	6.7%
CR_517	1.653	3.14%	6.085	0.86%	0.073	2.40%	991	20	981	8	1012	48	3.1%
CR_484	1.902	3.22%	5.661	1.04%	0.078	2.43%	1082	21	1049	10	1149	48	8.7%
CR_472	3.628	3.29%	3.838	1.29%	0.101	2.39%	1556	26	1493	17	1642	44	9.1%
CR_463	1.824	3.26%	5.636	1.15%	0.075	2.44%	1054	21	1053	11	1057	48	0.4%
CR_416	2.467	3.19%	4.774	1.03%	0.085	2.39%	1262	23	1226	11	1325	46	7.5%
CR_500	1.802	3.15%	5.740	0.89%	0.075	2.39%	1046	20	1035	9	1069	47	3.2%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
CR_141	1.830	3.40%	5.661	1.24%	0.075	2.53%	1056	22	1049	12	1072	50	2.2%
CR_146	12.650	3.48%	1.947	1.59%	0.179	2.42%	2654	32	2672	35	2640	40	-1.2%
CR_200	2.393	3.50%	4.775	1.42%	0.083	2.58%	1240	25	1226	16	1266	50	3.2%
CR_280	3.232	3.52%	4.094	1.59%	0.096	2.48%	1465	27	1409	20	1547	46	8.9%
CR_271	1.579	3.22%	6.199	0.87%	0.071	2.44%	962	20	964	8	957	49	-0.8%
CR_452	3.630	3.26%	3.696	1.00%	0.097	2.44%	1556	26	1544	14	1573	45	1.9%
CR_446	1.594	3.23%	6.277	0.89%	0.073	2.46%	968	20	953	8	1001	49	4.8%
CR_679	2.327	4.21%	4.829	1.30%	0.081	3.17%	1220	29	1213	14	1233	61	1.6%
CR_639	1.861	4.08%	5.521	0.97%	0.075	3.10%	1067	27	1073	10	1055	61	-1.7%
CR_643	1.833	4.13%	5.623	1.06%	0.075	3.14%	1057	27	1055	10	1062	62	0.6%
CR_597a	12.671	4.19%	1.974	1.34%	0.181	3.11%	2656	39	2642	29	2666	51	0.9%
CR_532	1.561	4.23%	6.235	1.34%	0.071	3.17%	955	26	959	12	945	64	-1.4%
CR_17	2.442	4.40%	4.705	1.70%	0.083	3.24%	1255	31	1242	19	1278	62	2.8%
CR_62	2.926	4.11%	4.194	1.06%	0.089	3.11%	1389	31	1378	13	1405	58	1.9%
CR_82	1.741	4.11%	5.811	0.99%	0.073	3.14%	1024	26	1024	9	1025	62	0.1%
CR_88	3.002	4.15%	4.144	1.19%	0.090	3.12%	1408	31	1393	15	1431	58	2.6%
CR_85	1.969	4.18%	5.414	1.19%	0.077	3.17%	1105	28	1093	12	1129	62	3.2%
CR_197	2.696	4.10%	4.339	1.03%	0.085	3.11%	1327	30	1337	12	1312	59	-1.9%
CR_835	3.080	1.66%	4.116	1.32%	0.092	0.83%	1428	13	1402	17	1466	16	4.4%
CR_816	13.334	1.85%	1.929	1.56%	0.187	0.83%	2704	17	2692	34	2712	14	0.7%
CR_734	13.089	2.02%	1.938	1.75%	0.184	0.84%	2686	19	2682	38	2689	14	0.3%
CR_766	1.764	1.63%	5.852	1.24%	0.075	0.92%	1032	11	1017	12	1065	18	4.5%
CR_762	2.081	2.03%	5.190	1.65%	0.078	1.08%	1143	14	1136	17	1156	21	1.7%
CR_748	11.532	1.59%	2.124	1.25%	0.178	0.80%	2567	15	2488	26	2631	13	5.4%
CR_728	12.176	1.66%	2.020	1.34%	0.178	0.80%	2618	15	2593	29	2638	13	1.7%
CR_724	11.715	1.61%	2.119	1.28%	0.180	0.80%	2582	15	2492	26	2653	13	6.1%
CR_686	1.686	1.68%	6.030	1.32%	0.074	0.88%	1003	11	989	12	1035	18	4.4%
CR_698	1.861	1.60%	5.620	1.22%	0.076	0.87%	1067	10	1056	12	1091	17	3.3%
CR_664	2.032	1.63%	5.355	1.24%	0.079	0.91%	1126	11	1104	13	1170	18	5.7%
CR_765	1.798	1.17%	5.693	0.97%	0.074	0.70%	1045	8	1043	9	1048	14	0.5%
CR_803	1.783	1.44%	5.771	1.23%	0.075	0.78%	1039	9	1030	12	1059	16	2.7%
CR_851	1.977	1.41%	5.318	1.19%	0.076	0.81%	1108	9	1111	12	1102	16	-0.8%
CR_842	2.766	1.58%	4.307	1.38%	0.086	0.81%	1346	12	1346	17	1347	16	0.1%
CR_809	12.684	2.30%	2.009	2.23%	0.185	0.51%	2656	21	2605	48	2696	8	3.4%
CR_814	1.747	1.09%	5.810	0.92%	0.074	0.61%	1026	7	1024	9	1031	12	0.7%
CR_829	3.167	0.95%	4.047	0.85%	0.093	0.43%	1449	7	1424	11	1487	8	4.3%
CR_850	1.689	1.20%	5.983	1.05%	0.073	0.62%	1004	8	996	10	1022	13	2.5%
CR_719	3.248	1.61%	3.899	1.54%	0.092	0.45%	1469	12	1472	20	1465	8	-0.5%
CR_699	2.274	2.21%	4.875	2.01%	0.080	0.92%	1204	15	1203	22	1207	18	0.3%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
CR_678	1.972	1.82%	5.347	1.67%	0.076	0.71%	1106	12	1105	17	1108	14	0.2%
CR_684	3.881	2.01%	3.577	1.88%	0.101	0.67%	1610	16	1589	26	1637	12	2.9%
CR_697	2.166	1.66%	5.027	1.57%	0.079	0.52%	1170	11	1169	17	1172	10	0.2%
CR_725	1.831	1.72%	5.570	1.60%	0.074	0.62%	1057	11	1064	16	1041	13	-2.2%
CR_742	2.823	1.83%	4.208	1.72%	0.086	0.59%	1362	14	1374	21	1342	11	-2.4%
CR_774	2.517	1.80%	4.552	1.70%	0.083	0.56%	1277	13	1280	20	1271	11	-0.7%
CR_783	1.737	1.33%	5.894	1.23%	0.074	0.47%	1022	9	1010	11	1049	10	3.7%
CR_806	3.103	1.47%	4.024	1.37%	0.091	0.47%	1433	11	1431	18	1437	9	0.4%
CR_709	12.300	1.70%	1.973	1.61%	0.176	0.47%	2628	16	2643	35	2616	8	-1.0%
CR_629	2.174	1.73%	4.955	1.63%	0.078	0.49%	1173	12	1185	18	1151	10	-3.0%
CR_646	1.765	2.01%	5.713	1.85%	0.073	0.74%	1033	13	1040	18	1018	15	-2.2%
CR_605	1.809	2.10%	5.655	1.91%	0.074	0.87%	1049	14	1050	18	1047	18	-0.3%
CR_566	3.088	1.47%	4.040	1.27%	0.090	0.67%	1430	11	1426	16	1436	13	0.7%
CR_622	2.782	1.50%	4.341	1.29%	0.088	0.70%	1351	11	1337	16	1373	13	2.7%
CR_875	1.753	1.43%	5.756	1.26%	0.073	0.60%	1028	9	1033	12	1019	12	-1.4%
CR_864	2.650	1.61%	4.443	1.40%	0.085	0.75%	1315	12	1308	17	1325	14	1.2%
CR_849	2.943	1.34%	4.173	1.16%	0.089	0.59%	1393	10	1385	14	1406	11	1.5%
CR_861	3.165	1.56%	3.965	1.38%	0.091	0.66%	1449	12	1450	18	1447	13	-0.2%
CR_776	1.827	1.45%	5.677	1.23%	0.075	0.70%	1055	9	1046	12	1075	14	2.7%
							>10% Discordant						
CR_33	1.806	1.39%	6.020	1.20%	0.079	0.66%	1048	9	991	11	1169	13	15.2%
CR_30	3.106	1.62%	4.225	1.44%	0.095	0.71%	1434	12	1369	18	1531	13	10.6%
CR_13	1.953	1.40%	5.920	1.23%	0.084	0.61%	1100	9	1006	11	1289	12	22.0%
CR_449	2.230	1.66%	5.175	1.46%	0.084	0.78%	1190	12	1139	15	1285	15	11.4%
CR_558	1.364	1.84%	13.208	1.75%	0.131	0.52%	874	11	470	8	2107	9	77.7%
CR_512	1.700	2.77%	9.252	2.12%	0.114	1.93%	1008	18	662	13	1865	34	64.5%
CR_460	1.778	3.17%	5.985	0.94%	0.077	2.40%	1037	20	996	9	1125	47	11.5%
CR_487	5.029	3.11%	2.844	0.67%	0.104	2.41%	1824	26	1942	11	1692	44	-14.8%
CR_314	2.042	3.19%	5.459	0.81%	0.081	2.42%	1130	21	1084	8	1218	47	11.0%
CR_405	1.511	3.45%	7.539	1.34%	0.083	2.55%	935	21	803	10	1260	49	36.3%
CR_493	11.041	3.27%	2.258	1.10%	0.181	2.41%	2527	30	2364	22	2660	39	11.1%
CR_485	8.025	3.23%	2.821	0.98%	0.164	2.40%	2234	29	1956	16	2500	40	21.8%
CR_877	3.256	1.37%	6.774	0.97%	0.160	1.05%	1471	11	888	8	2456	18	63.9%
CR_880	1.633	4.62%	6.773	4.10%	0.080	2.23%	983	29	888	34	1202	43	26.2%
CR_764	2.577	1.66%	8.707	1.59%	0.163	0.43%	1294	12	701	11	2485	7	71.8%
CR_800	1.856	1.69%	6.275	1.60%	0.084	0.50%	1065	11	953	14	1303	10	26.8%
CR_817	2.237	2.02%	6.586	1.87%	0.107	0.70%	1193	14	911	16	1746	13	47.8%
CR_798	2.768	1.92%	4.798	1.75%	0.096	0.76%	1347	14	1220	19	1554	14	21.5%
CR_714	10.194	1.69%	2.350	1.59%	0.174	0.47%	2453	15	2285	31	2594	8	11.9%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
CR_543	2.871	1.63%	10.504	1.45%	0.219	0.71%	1374	12	586	8	2971	11	80.3%
CR_832	2.463	1.61%	6.101	1.21%	0.109	1.08%	1261	12	978	11	1782	20	45.1%

APPENDIX G

Data Tables for Sample USSB –

Lower Basal Oil Creek Sandstone,

Oil Creek Formation, Simpson Group

Sample USSB - Lower Basal Oil Creek Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
USSB_52	13.506	1.27%	1.907	1.14%	0.187	0.52%	2716	12	2718	25	2714	9	-0.1%
USSB_36	5.331	1.40%	2.948	1.24%	0.114	0.64%	1874	12	1883	20	1864	12	-1.0%
USSB_25	13.314	1.55%	1.895	1.43%	0.183	0.56%	2702	14	2732	32	2680	9	-1.9%
USSB_12	5.755	1.12%	2.882	0.97%	0.120	0.53%	1940	10	1920	16	1961	10	2.1%
USSB_22	13.709	1.52%	1.881	1.40%	0.187	0.57%	2730	14	2749	31	2716	9	-1.2%
USSB_16	13.322	1.60%	2.033	1.41%	0.196	0.79%	2703	15	2579	30	2797	13	7.8%
USSB_9	13.323	1.40%	1.922	1.27%	0.186	0.55%	2703	13	2701	28	2704	9	0.1%
USSB_8	12.374	1.05%	2.011	0.91%	0.180	0.49%	2633	10	2602	19	2657	8	2.1%
USSB_7	14.474	1.87%	1.821	1.76%	0.191	0.61%	2781	18	2822	40	2752	10	-2.5%
USSB_2	13.549	1.33%	1.927	1.19%	0.189	0.56%	2719	12	2695	26	2737	9	1.5%
USSB_1	4.804	1.42%	3.235	1.26%	0.113	0.66%	1786	12	1737	19	1844	12	5.8%
USSB_142	13.500	1.89%	1.883	1.79%	0.184	0.63%	2715	18	2746	40	2693	10	-2.0%
USSB_111	13.756	1.49%	1.879	1.37%	0.187	0.60%	2733	14	2751	31	2720	10	-1.1%
USSB_61	5.244	1.58%	3.011	1.46%	0.115	0.63%	1860	13	1849	23	1872	11	1.3%
USSB_40	5.163	1.68%	3.024	1.56%	0.113	0.64%	1847	14	1842	25	1852	12	0.6%
USSB_24	14.568	1.40%	1.852	1.29%	0.196	0.53%	2787	13	2783	29	2790	9	0.2%
USSB_69	14.144	1.77%	1.841	1.66%	0.189	0.60%	2759	17	2797	38	2732	10	-2.4%
USSB_79	13.928	1.62%	1.877	1.48%	0.190	0.66%	2745	15	2754	33	2739	11	-0.5%
USSB_68	13.306	1.63%	1.900	1.52%	0.183	0.58%	2702	15	2725	34	2684	10	-1.5%
USSB_74	12.685	1.56%	1.954	1.46%	0.180	0.55%	2657	15	2664	32	2651	9	-0.5%
USSB_73	15.030	1.69%	1.829	1.59%	0.199	0.56%	2817	16	2811	36	2821	9	0.3%
USSB_63	13.386	2.30%	1.915	2.21%	0.186	0.64%	2707	21	2708	49	2706	11	-0.1%
USSB_110	13.491	1.28%	1.897	1.15%	0.186	0.53%	2715	12	2730	26	2704	9	-1.0%
USSB_123	13.555	1.10%	1.915	0.97%	0.188	0.51%	2719	10	2709	21	2727	8	0.7%
USSB_153	14.312	1.80%	1.833	1.71%	0.190	0.59%	2771	17	2807	39	2744	10	-2.3%
USSB_155	13.600	1.29%	1.887	1.17%	0.186	0.53%	2722	12	2741	26	2708	9	-1.2%
USSB_139	14.255	1.49%	1.863	1.34%	0.193	0.67%	2767	14	2770	30	2765	11	-0.2%
USSB_150	13.088	1.48%	1.976	1.36%	0.188	0.57%	2686	14	2640	29	2721	9	3.0%
USSB_135	13.216	1.29%	1.945	1.17%	0.186	0.50%	2695	12	2674	26	2711	8	1.4%
USSB_107	5.354	1.72%	2.972	1.55%	0.115	0.79%	1878	15	1870	25	1886	14	0.9%
USSB_109	14.125	1.43%	1.894	1.31%	0.194	0.57%	2758	13	2733	29	2777	9	1.6%
USSB_97	14.126	2.00%	1.836	1.88%	0.188	0.71%	2758	19	2803	43	2726	12	-2.8%
USSB_33	13.167	1.34%	1.950	1.14%	0.186	0.62%	2692	13	2669	25	2709	10	1.5%
USSB_23	5.096	1.28%	3.047	1.07%	0.113	0.63%	1835	11	1830	17	1842	11	0.7%
USSB_19	4.922	1.44%	3.130	1.23%	0.112	0.71%	1806	12	1787	19	1828	13	2.2%
USSB_11	12.984	2.08%	1.955	1.94%	0.184	0.71%	2678	19	2663	42	2691	12	1.0%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
USSB_6	13.466	1.44%	1.925	1.25%	0.188	0.67%	2713	14	2697	27	2725	11	1.0%
USSB_35	4.928	1.23%	3.154	1.02%	0.113	0.63%	1807	10	1775	16	1844	11	3.7%
USSB_91	13.214	1.29%	1.932	1.10%	0.185	0.59%	2695	12	2689	24	2700	10	0.4%
USSB_101	13.384	1.29%	1.928	1.10%	0.187	0.60%	2707	12	2694	24	2717	10	0.9%
USSB_105	13.157	1.95%	1.940	1.80%	0.185	0.71%	2691	18	2680	39	2700	12	0.7%
USSB_98	4.892	1.81%	3.098	1.60%	0.110	0.83%	1801	15	1803	25	1798	15	-0.3%
USSB_82	4.997	1.36%	3.106	1.15%	0.113	0.69%	1819	11	1800	18	1841	12	2.3%
USSB_72	13.074	1.51%	1.951	1.38%	0.185	0.57%	2685	14	2667	30	2699	9	1.2%
USSB_57	12.919	1.45%	1.963	1.33%	0.184	0.53%	2674	14	2654	29	2689	9	1.3%
USSB_53	5.021	1.26%	3.084	1.10%	0.112	0.58%	1823	11	1811	17	1837	10	1.4%
USSB_42	13.131	1.30%	1.952	1.16%	0.186	0.55%	2689	12	2666	25	2707	9	1.5%
USSB_45	13.291	1.41%	1.937	1.29%	0.187	0.51%	2701	13	2683	28	2714	8	1.1%
USSB_37	12.665	1.20%	2.013	1.07%	0.185	0.49%	2655	11	2600	23	2698	8	3.6%
USSB_18	1.911	1.33%	5.426	1.11%	0.075	0.74%	1085	9	1091	11	1074	15	-1.6%
USSB_29	13.916	1.60%	1.891	1.47%	0.191	0.58%	2744	15	2737	33	2750	10	0.5%
USSB_14	12.910	1.62%	1.951	1.50%	0.183	0.58%	2673	15	2667	33	2678	10	0.4%
USSB_27	4.984	1.65%	3.100	1.46%	0.112	0.78%	1817	14	1802	23	1833	14	1.7%
USSB_93	5.069	1.33%	3.091	1.25%	0.114	0.44%	1831	11	1807	20	1858	8	2.8%
USSB_112	1.940	1.70%	5.399	1.52%	0.076	0.83%	1095	11	1096	15	1094	17	-0.1%
USSB_136	13.421	1.65%	1.933	1.58%	0.188	0.47%	2710	15	2688	35	2726	8	1.4%
USSB_133	12.898	1.49%	2.005	1.41%	0.188	0.45%	2672	14	2608	30	2721	7	4.2%
USSB_122	12.889	1.36%	1.943	1.29%	0.182	0.41%	2672	13	2677	28	2667	7	-0.4%
USSB_81	1.855	1.79%	5.628	1.57%	0.076	0.95%	1065	12	1054	15	1087	19	3.0%
USSB_77	1.955	1.54%	5.319	1.38%	0.075	0.73%	1100	10	1111	14	1079	15	-2.9%
USSB_83	13.571	1.86%	1.911	1.78%	0.188	0.53%	2720	17	2713	39	2726	9	0.5%
USSB_160	13.579	1.61%	1.891	1.50%	0.186	0.54%	2721	15	2736	33	2709	9	-1.0%
USSB_157	15.499	1.64%	1.804	1.54%	0.203	0.53%	2846	16	2843	35	2849	9	0.2%
USSB_182	13.649	1.27%	1.881	1.17%	0.186	0.43%	2726	12	2748	26	2709	7	-1.4%
USSB_200	5.228	1.48%	3.009	1.35%	0.114	0.60%	1857	13	1850	22	1866	11	0.9%
USSB_239	12.276	1.36%	2.077	1.25%	0.185	0.48%	2626	13	2533	26	2698	8	6.1%
USSB_225	12.951	1.54%	1.950	1.43%	0.183	0.53%	2676	14	2669	31	2681	9	0.5%
USSB_215	13.175	1.55%	1.922	1.45%	0.184	0.48%	2692	15	2701	32	2686	8	-0.5%
USSB_203	13.545	1.39%	1.896	1.30%	0.186	0.46%	2718	13	2730	29	2710	8	-0.8%
USSB_163	13.443	1.44%	1.904	1.34%	0.186	0.51%	2711	14	2721	30	2704	8	-0.6%
USSB_246	12.929	2.07%	1.958	2.00%	0.184	0.48%	2674	19	2659	43	2686	8	1.0%
USSB_212	1.997	2.47%	5.167	2.24%	0.075	1.15%	1115	17	1141	23	1065	23	-7.2%
USSB_210	13.489	1.95%	1.902	1.89%	0.186	0.46%	2715	18	2723	42	2708	8	-0.5%
USSB_202	13.632	2.12%	1.875	2.05%	0.185	0.48%	2724	20	2756	46	2701	8	-2.0%
USSB_180	13.723	2.24%	1.861	2.18%	0.185	0.50%	2731	21	2772	49	2701	8	-2.6%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
USSB_167	12.927	1.80%	1.950	1.75%	0.183	0.39%	2674	17	2669	38	2679	6	0.4%
USSB_171	12.543	1.78%	1.970	1.73%	0.179	0.35%	2646	17	2646	38	2646	6	0.0%
USSB_156	6.161	1.87%	2.801	1.80%	0.125	0.48%	1999	16	1968	30	2031	9	3.1%
USSB_145	12.589	1.97%	2.089	1.91%	0.191	0.45%	2649	18	2522	40	2748	7	8.2%
USSB_140	12.356	1.74%	1.967	1.69%	0.176	0.34%	2632	16	2650	37	2618	6	-1.2%
USSB_296	13.770	1.09%	1.875	0.95%	0.187	0.51%	2734	10	2756	21	2718	8	-1.4%
USSB_293	13.071	1.11%	1.930	0.96%	0.183	0.55%	2685	10	2692	21	2680	9	-0.5%
USSB_291	13.786	1.25%	1.879	1.11%	0.188	0.57%	2735	12	2751	25	2724	9	-1.0%
USSB_282	4.972	1.11%	3.095	0.95%	0.112	0.56%	1815	9	1805	15	1826	10	1.2%
USSB_281	13.742	1.23%	1.888	1.09%	0.188	0.57%	2732	12	2740	24	2726	9	-0.5%
USSB_267	13.150	1.28%	1.891	1.14%	0.180	0.58%	2690	12	2736	25	2656	10	-3.0%
USSB_255	13.420	1.21%	1.917	1.07%	0.187	0.53%	2710	11	2707	24	2712	9	0.2%
USSB_250	14.473	1.13%	1.863	0.97%	0.196	0.55%	2781	11	2770	22	2789	9	0.7%
USSB_236	5.311	1.27%	2.945	1.08%	0.113	0.68%	1871	11	1885	18	1855	12	-1.6%
USSB_231	14.061	1.96%	1.798	1.83%	0.183	0.68%	2754	18	2851	42	2683	11	-6.2%
USSB_256	14.005	1.47%	1.867	1.41%	0.190	0.45%	2750	14	2765	32	2739	7	-1.0%
USSB_253	13.403	1.29%	1.907	1.23%	0.185	0.39%	2708	12	2718	27	2701	6	-0.6%
USSB_263	4.924	1.35%	3.136	1.28%	0.112	0.48%	1806	11	1784	20	1832	9	2.6%
USSB_266	13.909	1.57%	1.862	1.51%	0.188	0.46%	2744	15	2771	34	2724	8	-1.7%
USSB_272	5.044	1.59%	3.055	1.49%	0.112	0.61%	1827	13	1826	24	1828	11	0.1%
USSB_277	20.386	1.67%	1.545	1.62%	0.228	0.43%	3110	16	3217	41	3041	7	-5.8%
USSB_280	1.868	1.49%	5.564	1.34%	0.075	0.75%	1070	10	1066	13	1079	15	1.3%
USSB_285	14.944	1.34%	1.820	1.29%	0.197	0.39%	2812	13	2823	29	2804	6	-0.7%
USSB_299	13.699	1.40%	1.903	1.34%	0.189	0.44%	2729	13	2723	30	2734	7	0.4%
USSB_242	13.242	2.18%	1.901	2.14%	0.183	0.51%	2697	20	2725	47	2676	8	-1.8%
USSB_232	13.827	2.28%	1.871	2.23%	0.188	0.55%	2738	21	2760	50	2722	9	-1.4%
USSB_233	13.094	1.88%	1.938	1.85%	0.184	0.39%	2686	18	2682	41	2690	6	0.3%
USSB_208	13.499	2.56%	1.886	2.52%	0.185	0.51%	2715	24	2742	56	2695	8	-1.7%
USSB_192	15.355	2.04%	1.846	2.00%	0.206	0.46%	2838	19	2791	45	2871	7	2.8%
USSB_191	13.312	2.05%	1.933	2.01%	0.187	0.48%	2702	19	2688	44	2712	8	0.9%
USSB_227	11.171	1.77%	2.054	1.73%	0.166	0.38%	2538	16	2558	37	2522	6	-1.4%
USSB_245	5.068	1.76%	3.083	1.71%	0.113	0.45%	1831	15	1811	27	1854	8	2.3%
							>10% Discordant						
USSB_94	11.418	1.65%	2.290	1.54%	0.190	0.59%	2558	15	2336	30	2739	10	14.7%
USSB_34	2.197	1.90%	11.215	1.34%	0.179	1.49%	1180	13	551	7	2641	25	79.1%
USSB_92	0.891	3.12%	20.498	3.07%	0.133	0.50%	647	15	307	9	2132	9	85.6%
USSB_146	2.879	1.68%	5.177	1.51%	0.108	0.82%	1376	13	1139	16	1767	15	35.6%
USSB_226	0.833	1.70%	32.212	1.59%	0.195	0.57%	615	8	197	3	2782	9	92.9%
USSB_287	3.067	2.22%	8.402	2.19%	0.187	0.38%	1424	17	725	15	2715	6	73.3%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
USSB_207	1.801	1.92%	14.604	1.88%	0.191	0.38%	1046	12	427	8	2749	6	84.5%

APPENDIX H

Data Tables for Sample BM –

Lower Basal McLish Sandstone,

McLish Formation, Simpson Group

Sample BM - Lower Basal McLish Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
BM_70	14.019	5.11%	1.819	3.97%	0.185	1.90%	2751	47	2824	90	2698	31	-4.7%
BM_19	13.839	4.92%	1.881	3.70%	0.189	1.92%	2739	46	2749	82	2731	31	-0.6%
BM_95	4.752	5.05%	3.145	3.87%	0.108	1.92%	1776	42	1780	60	1772	35	-0.4%
BM_56	1.883	5.00%	5.675	3.76%	0.078	1.99%	1075	33	1046	36	1134	39	7.7%
BM_54	13.170	5.00%	1.955	3.78%	0.187	1.95%	2692	46	2663	82	2713	32	1.8%
BM_52	13.127	5.14%	1.947	4.00%	0.185	1.92%	2689	47	2672	87	2701	31	1.1%
BM_40	14.755	4.95%	1.855	3.75%	0.198	1.91%	2800	46	2780	84	2814	31	1.2%
BM_35	13.476	4.94%	1.928	3.73%	0.188	1.91%	2714	46	2693	82	2729	31	1.3%
BM_36	3.022	5.10%	4.070	3.90%	0.089	1.97%	1413	38	1416	49	1408	37	-0.6%
BM_113	12.074	4.14%	2.052	3.03%	0.180	1.64%	2610	38	2559	64	2651	27	3.5%
BM_142	4.776	3.82%	3.205	2.57%	0.111	1.66%	1781	32	1750	39	1817	30	3.7%
BM_120	13.202	3.91%	2.008	2.70%	0.192	1.65%	2694	36	2605	58	2762	27	5.7%
BM_138	12.373	3.94%	2.041	2.75%	0.183	1.65%	2633	36	2571	58	2682	27	4.1%
BM_149	13.297	3.99%	1.919	2.82%	0.185	1.65%	2701	37	2703	62	2700	27	-0.1%
BM_86	15.767	3.92%	1.797	2.74%	0.206	1.63%	2863	37	2852	63	2870	26	0.6%
BM_78	13.175	4.12%	1.946	2.99%	0.186	1.67%	2692	38	2673	65	2707	27	1.3%
BM_242	3.098	5.04%	4.158	4.03%	0.093	1.72%	1432	38	1389	50	1497	32	7.2%
BM_127	3.948	4.92%	3.562	3.87%	0.102	1.74%	1624	39	1595	54	1661	32	3.9%
BM_183	12.224	4.78%	2.095	3.74%	0.186	1.69%	2622	44	2516	77	2705	28	7.0%
BM_151	5.150	4.85%	3.089	3.81%	0.115	1.71%	1844	40	1808	60	1886	30	4.1%
BM_43	2.896	4.85%	4.244	3.78%	0.089	1.74%	1381	36	1364	46	1407	33	3.1%
BM_72	12.443	4.77%	2.043	3.72%	0.184	1.69%	2638	44	2568	78	2693	28	4.6%
BM_119	12.525	4.77%	2.026	3.73%	0.184	1.68%	2645	44	2586	79	2690	27	3.9%
BM_99	12.131	4.82%	2.071	3.78%	0.182	1.70%	2615	44	2540	79	2673	28	5.0%
BM_74	3.589	4.80%	3.873	3.74%	0.101	1.71%	1547	37	1481	49	1639	31	9.7%
BM_76	13.393	4.75%	1.943	4.41%	0.189	1.08%	2708	44	2677	96	2731	18	2.0%
BM_84	14.507	4.73%	1.911	4.40%	0.201	1.04%	2783	44	2713	97	2835	17	4.3%
BM_87	12.509	4.86%	2.059	4.55%	0.187	1.03%	2643	45	2551	95	2715	17	6.0%
BM_117	2.531	4.78%	4.679	4.41%	0.086	1.16%	1281	34	1249	50	1336	22	6.5%
BM_145	4.167	4.87%	3.429	4.51%	0.104	1.14%	1667	39	1650	65	1690	21	2.4%
BM_147	3.854	4.89%	3.648	4.56%	0.102	1.09%	1604	39	1562	63	1660	20	5.9%
BM_949	12.002	2.37%	2.083	2.09%	0.181	0.70%	2605	22	2528	44	2665	12	5.1%
BM_888	2.824	2.36%	4.255	2.02%	0.087	0.83%	1362	18	1361	25	1364	16	0.3%
BM_813	12.514	2.27%	2.018	2.03%	0.183	0.61%	2644	21	2595	43	2681	10	3.2%
BM_787	12.059	2.29%	2.110	2.03%	0.185	0.65%	2609	21	2501	42	2694	11	7.1%
BM_707	3.842	2.48%	3.573	2.19%	0.100	0.75%	1602	20	1591	31	1616	14	1.5%

Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	age (Ma)	1-σ (Ma)	age (Ma)	1-σ (Ma)	age (Ma)	1-σ (Ma)	Discordance (%)
BM_692	13.392	2.52%	1.913	2.26%	0.186	0.70%	2708	24	2711	50	2705	12	-0.2%
BM_772	2.560	2.55%	4.560	2.11%	0.085	1.03%	1289	18	1278	24	1308	20	2.3%
BM_779	2.572	2.31%	4.581	1.94%	0.085	0.86%	1293	17	1273	22	1326	17	4.0%
BM_749	4.120	2.30%	3.395	1.94%	0.101	0.85%	1658	19	1664	28	1650	16	-0.8%
BM_664	13.215	2.22%	1.943	1.95%	0.186	0.66%	2695	21	2676	43	2709	11	1.2%
BM_697	2.563	2.46%	4.505	1.99%	0.084	1.04%	1290	18	1292	23	1286	20	-0.5%
BM_1074	12.654	3.02%	2.002	1.90%	0.184	1.40%	2654	28	2612	41	2686	23	2.8%
BM_1039	1.844	3.00%	5.630	1.72%	0.075	1.53%	1061	20	1054	17	1076	30	2.1%
BM_972	3.749	3.03%	3.782	1.87%	0.103	1.44%	1582	24	1512	25	1676	26	9.8%
BM_921	2.774	3.17%	4.373	1.93%	0.088	1.59%	1348	23	1328	23	1382	30	3.9%
BM_875	2.373	3.03%	4.770	1.82%	0.082	1.49%	1235	21	1227	20	1248	29	1.7%
BM_863	2.755	3.57%	4.463	2.26%	0.089	1.85%	1343	26	1303	27	1408	35	7.4%
BM_854	13.517	2.96%	2.001	1.80%	0.196	1.40%	2716	28	2613	38	2794	23	6.5%
BM_821	12.248	2.86%	2.047	1.69%	0.182	1.36%	2624	27	2564	36	2670	22	3.9%
BM_1354	12.737	1.97%	2.013	1.07%	0.186	0.99%	2660	18	2600	23	2707	16	4.0%
BM_1332	12.532	2.12%	2.075	1.25%	0.189	1.05%	2645	20	2536	26	2730	17	7.1%
BM_1296	12.858	1.98%	2.029	1.06%	0.189	1.00%	2669	18	2583	22	2735	16	5.6%
BM_1226	3.778	1.91%	3.668	0.91%	0.101	1.02%	1588	15	1554	13	1634	19	4.9%
BM_1173	2.856	3.26%	4.324	2.08%	0.090	1.83%	1370	24	1341	25	1416	35	5.3%
BM_1188	3.597	2.55%	3.642	1.81%	0.095	1.15%	1549	20	1564	25	1529	22	-2.3%
BM_1001	14.980	3.00%	1.796	2.82%	0.195	0.66%	2814	28	2853	65	2786	11	-2.4%
BM_967	12.750	2.93%	2.009	2.72%	0.186	0.71%	2661	27	2604	58	2705	12	3.7%
BM_1044	4.298	2.85%	3.436	2.59%	0.107	0.81%	1693	23	1647	37	1751	15	5.9%
BM_1271	12.690	3.11%	1.997	2.88%	0.184	0.81%	2657	29	2617	62	2688	13	2.6%
BM_1212	12.838	3.03%	2.060	2.82%	0.192	0.73%	2668	28	2551	59	2757	12	7.5%
BM_1375	5.125	2.72%	3.085	2.46%	0.115	0.78%	1840	23	1810	39	1875	14	3.5%
BM_1368	12.690	2.82%	2.048	2.57%	0.189	0.77%	2657	26	2563	54	2729	13	6.1%
BM_867	2.912	3.60%	4.198	2.97%	0.089	1.55%	1385	27	1377	37	1397	30	1.4%
BM_1040	11.742	2.29%	2.177	2.05%	0.185	0.65%	2584	21	2437	42	2702	11	9.8%
BM_1094	12.194	2.23%	2.100	2.01%	0.186	0.59%	2619	21	2511	42	2704	10	7.1%
BM_1289	12.190	2.72%	2.103	2.41%	0.186	0.86%	2619	25	2508	50	2706	14	7.3%
BM_1115	12.480	2.44%	2.088	2.20%	0.189	0.69%	2641	23	2523	46	2733	11	7.7%
BM_1210	12.713	2.49%	2.011	2.23%	0.185	0.73%	2659	23	2602	48	2702	12	3.7%
BM_1533	13.867	3.90%	1.871	3.56%	0.188	0.94%	2741	36	2760	79	2726	15	-1.3%
BM_1564	12.633	3.54%	2.000	3.18%	0.183	0.89%	2653	33	2614	68	2682	15	2.6%
BM_1539	12.361	3.57%	2.072	3.22%	0.186	0.90%	2632	33	2539	67	2704	15	6.1%
BM_1531	13.103	3.57%	1.992	3.22%	0.189	0.90%	2687	33	2622	69	2736	15	4.2%
BM_1506	12.571	3.57%	2.029	3.22%	0.185	0.89%	2648	33	2583	68	2698	15	4.3%
BM_1350	12.753	3.58%	2.002	3.23%	0.185	0.89%	2662	33	2612	69	2700	15	3.3%
BM_1303	1.714	3.68%	5.928	3.24%	0.074	1.11%	1014	23	1005	30	1033	22	2.7%

Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	age (Ma)	1-σ (Ma)	age (Ma)	1-σ (Ma)	age (Ma)	1-σ (Ma)	Discordance (%)
BM_733	5.002	3.88%	3.056	3.57%	0.111	0.94%	1820	32	1825	56	1814	17	-0.6%
BM_763	12.572	3.41%	1.982	3.06%	0.181	0.92%	2648	32	2633	66	2660	15	1.0%
BM_804	3.741	2.63%	3.644	2.20%	0.099	0.90%	1580	21	1563	30	1603	17	2.5%
BM_647	12.750	2.59%	2.021	2.16%	0.187	0.87%	2661	24	2591	46	2715	14	4.6%
BM_670	2.830	2.77%	4.341	2.21%	0.089	1.11%	1364	21	1337	27	1406	21	5.0%
BM_1706	13.940	2.59%	1.957	2.15%	0.198	0.88%	2746	24	2661	47	2808	14	5.2%
BM_1699	12.064	2.51%	2.062	2.09%	0.180	0.84%	2609	23	2549	44	2656	14	4.0%
BM_1717	2.522	2.54%	4.652	2.10%	0.085	0.88%	1279	18	1255	24	1318	17	4.8%
							>10% Discordant						
BM_41	3.011	6.08%	9.217	5.14%	0.201	1.92%	1410	45	664	32	2837	31	76.6%
BM_131	3.918	4.42%	3.710	3.38%	0.105	1.66%	1617	35	1539	46	1722	30	10.6%
BM_64	3.013	4.35%	4.660	3.27%	0.102	1.68%	1411	33	1253	37	1658	31	24.4%
BM_45	10.294	3.89%	2.487	2.69%	0.186	1.63%	2462	35	2179	49	2705	27	19.4%
BM_152	8.816	5.12%	2.848	4.14%	0.182	1.71%	2319	46	1940	69	2672	28	27.4%
BM_60	10.582	4.81%	2.393	4.50%	0.184	1.00%	2487	44	2251	85	2686	16	16.2%
BM_104	8.541	4.76%	3.003	4.44%	0.186	1.04%	2290	42	1853	71	2707	17	31.5%
BM_164	10.460	5.67%	2.456	5.41%	0.186	1.01%	2476	51	2202	100	2710	17	18.7%
BM_68	4.679	6.37%	5.430	6.14%	0.184	1.00%	1764	52	1090	61	2692	16	59.5%
BM_1026	17.556	3.77%	1.533	2.99%	0.195	1.36%	2966	36	3238	76	2786	22	-16.2%
BM_1013	3.472	5.63%	7.350	5.14%	0.185	1.35%	1521	43	822	40	2699	22	69.5%
BM_993	1.565	9.63%	16.055	9.35%	0.182	1.34%	956	58	390	35	2673	22	85.4%
BM_1378	11.239	1.94%	2.324	1.02%	0.189	0.98%	2543	18	2307	20	2737	16	15.7%
BM_1355	3.163	2.01%	4.538	1.03%	0.104	1.06%	1448	15	1284	12	1699	19	24.4%
BM_1321	2.392	2.05%	4.939	1.02%	0.086	1.12%	1240	15	1189	11	1331	22	10.7%
BM_1316	4.087	2.04%	3.689	1.14%	0.109	1.03%	1652	16	1546	16	1789	19	13.5%
BM_1273	12.181	2.05%	2.152	1.12%	0.190	1.05%	2618	19	2460	23	2743	17	10.3%
BM_1009	5.599	3.25%	4.524	3.09%	0.184	0.65%	1916	28	1287	36	2687	11	52.1%
BM_1106	9.400	2.95%	2.703	2.72%	0.184	0.77%	2378	27	2029	47	2692	13	24.6%
BM_1204	10.454	2.73%	2.461	2.53%	0.187	0.65%	2476	25	2198	47	2712	11	19.0%
BM_1353	0.715	14.85%	35.495	14.89%	0.184	0.67%	548	61	179	26	2690	11	93.3%
BM_942	5.867	3.60%	4.842	2.72%	0.206	1.82%	1956	31	1210	30	2875	29	57.9%
BM_1125	2.164	2.43%	6.292	2.11%	0.099	0.84%	1170	17	951	19	1601	16	40.6%
BM_1263b	515.251	5.60%	0.223	5.52%	0.835	0.58%	6343	55	10962	284	4982	8	-120.0%
BM_1263	14.547	3.13%	2.034	2.30%	0.215	1.63%	2786	29	2578	49	2940	26	12.3%
BM_1233	26.517	4.37%	2.673	3.79%	0.514	1.66%	3366	42	2049	66	4282	24	52.2%
BM_1447	0.693	3.58%	28.162	3.22%	0.142	0.93%	535	15	225	7	2246	16	90.0%
BM_1163	4.181	2.54%	3.654	2.17%	0.111	0.93%	1670	21	1559	30	1813	17	14.0%
BM_1497	1.353	4.54%	10.243	4.25%	0.101	0.93%	869	26	600	24	1634	17	63.2%
BM_1510	4.560	5.75%	6.041	5.51%	0.200	0.93%	1742	47	988	50	2824	15	65.0%
BM_1507	9.474	3.59%	2.646	3.24%	0.182	0.89%	2385	32	2066	57	2669	15	22.6%

Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	age (Ma)	1-σ (Ma)	age (Ma)	1-σ (Ma)	age (Ma)	1-σ (Ma)	Discordance (%)
BM_830	4.360	3.78%	3.691	3.47%	0.117	0.89%	1705	31	1545	48	1907	16	19.0%
BM_1687	11.319	2.61%	2.238	2.20%	0.184	0.82%	2550	24	2381	44	2687	14	11.4%
BM_1668	10.195	2.57%	2.501	2.12%	0.185	0.90%	2453	24	2168	39	2698	15	19.6%

APPENDIX I

Data Tables for Sample TM –

Upper Basal McLish Sandstone,

McLish Formation, Simpson Group

Sample TM - Upper Basal McLish Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
TM_19	3.528	3.06%	3.702	1.70%	0.095	1.59%	1533	24	1541	23	1523	30	-1.2%
TM_36	13.958	3.02%	1.839	1.68%	0.186	1.55%	2747	28	2799	38	2709	25	-3.3%
TM_30	4.947	3.05%	3.017	1.70%	0.108	1.58%	1810	25	1845	27	1770	29	-4.2%
TM_133	13.985	3.18%	1.861	1.93%	0.189	1.57%	2749	30	2772	43	2732	26	-1.5%
TM_138	14.626	3.18%	1.753	1.93%	0.186	1.56%	2791	30	2910	45	2706	25	-7.5%
TM_78	14.058	3.05%	1.79	1.72%	0.183	1.55%	2754	28	2861	40	2676	25	-6.9%
TM_65	3.097	3.11%	3.928	1.76%	0.088	1.61%	1432	24	1462	23	1388	31	-5.3%
TM_111	4.182	3.11%	3.308	1.80%	0.100	1.58%	1670	25	1703	27	1631	29	-4.4%
TM_82	14.350	3.10%	1.81	1.80%	0.188	1.55%	2773	29	2836	41	2728	25	-3.9%
TM_278	14.024	2.89%	1.83	2.71%	0.186	0.64%	2751	27	2810	61	2709	11	-3.7%
TM_236	14.110	2.89%	1.834	2.70%	0.188	0.66%	2757	27	2805	61	2722	11	-3.0%
TM_253	13.549	2.88%	1.864	2.70%	0.183	0.66%	2719	27	2769	61	2681	11	-3.3%
TM_257	13.809	2.89%	1.82	2.70%	0.182	0.67%	2737	27	2823	62	2673	11	-5.6%
TM_233	3.309	2.93%	3.796	2.73%	0.091	0.71%	1483	23	1507	37	1449	13	-4.0%
TM_150	14.013	2.89%	1.839	2.70%	0.187	0.66%	2751	27	2799	61	2715	11	-3.1%
TM_180	14.312	2.89%	1.829	2.71%	0.190	0.66%	2771	27	2812	61	2741	11	-2.6%
TM_96	14.085	2.88%	1.824	2.70%	0.186	0.65%	2755	27	2818	61	2710	11	-4.0%
TM_126	13.897	2.90%	1.867	2.71%	0.188	0.67%	2743	27	2765	61	2726	11	-1.4%
TM_74	2.103	3.02%	5.114	2.75%	0.078	0.90%	1150	21	1151	29	1147	18	-0.4%
TM_771	13.693	2.02%	1.877	1.83%	0.186	0.58%	2729	19	2753	41	2711	9	-1.5%
TM_722	4.966	2.04%	3.054	1.84%	0.110	0.59%	1814	17	1826	29	1799	11	-1.5%
TM_600	4.991	1.96%	3.073	1.77%	0.111	0.56%	1818	16	1816	28	1820	10	0.2%
TM_663	13.959	2.03%	1.832	1.83%	0.185	0.58%	2747	19	2808	42	2703	10	-3.9%
TM_529	13.471	2.01%	1.878	1.82%	0.184	0.56%	2713	19	2752	41	2685	9	-2.5%
TM_485	13.976	2.05%	1.842	1.84%	0.187	0.62%	2748	19	2796	42	2713	10	-3.0%
TM_585	13.643	2.45%	1.876	2.23%	0.186	0.74%	2725	23	2754	50	2704	12	-1.9%
TM_305	2.784	2.02%	4.286	1.80%	0.087	0.62%	1351	15	1352	22	1350	12	-0.1%
TM_255	13.654	1.96%	1.874	1.78%	0.186	0.53%	2726	18	2757	40	2704	9	-2.0%
TM_454	13.094	1.56%	2.042	1.38%	0.194	0.48%	2686	15	2569	29	2776	8	7.4%
TM_495	12.035	1.46%	2.135	1.27%	0.186	0.49%	2607	14	2477	26	2710	8	8.6%
TM_751	2.790	1.56%	4.24	1.29%	0.086	0.65%	1353	12	1365	16	1333	13	-2.4%
TM_566	13.538	1.48%	1.884	1.27%	0.185	0.52%	2718	14	2745	28	2698	9	-1.7%
TM_642	13.988	1.46%	1.867	1.26%	0.189	0.51%	2749	14	2765	28	2737	8	-1.1%
TM_842	5.449	1.45%	2.875	1.26%	0.114	0.48%	1893	12	1924	21	1858	9	-3.6%
TM_387	5.048	1.62%	3.128	1.51%	0.115	0.40%	1827	14	1788	24	1872	7	4.5%
TM_314	14.220	1.67%	1.796	1.57%	0.185	0.40%	2764	16	2853	36	2700	7	-5.7%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
TM_462	1.844	2.11%	5.625	1.86%	0.075	0.81%	1061	14	1055	18	1074	16	1.8%
TM_536	15.502	1.67%	1.716	1.57%	0.193	0.40%	2847	16	2960	37	2767	7	-7.0%
TM_421	16.054	1.91%	1.818	1.81%	0.212	0.42%	2880	18	2826	41	2918	7	3.2%
TM_473	14.320	1.76%	1.775	1.66%	0.184	0.40%	2771	17	2881	38	2692	7	-7.0%
TM_434	3.273	1.94%	3.821	1.76%	0.091	0.65%	1475	15	1499	23	1440	12	-4.1%
TM_292	12.597	1.67%	1.997	1.57%	0.182	0.42%	2650	16	2617	34	2675	7	2.2%
TM_333	14.131	1.72%	1.824	1.61%	0.187	0.45%	2759	16	2818	37	2715	7	-3.8%
TM_799	4.151	1.47%	3.361	1.22%	0.101	0.55%	1664	12	1679	18	1646	10	-2.0%
TM_778	15.083	1.41%	1.721	1.17%	0.188	0.52%	2820	13	2953	28	2727	9	-8.3%
TM_441	13.420	1.49%	1.863	1.26%	0.181	0.54%	2710	14	2770	28	2665	9	-3.9%
TM_612	14.649	1.57%	1.792	1.32%	0.190	0.58%	2793	15	2859	31	2745	9	-4.1%
TM_608	14.332	1.46%	1.776	1.22%	0.185	0.54%	2772	14	2879	28	2694	9	-6.9%
TM_496	14.374	1.38%	1.767	1.15%	0.184	0.50%	2775	13	2891	27	2691	8	-7.4%
TM_362	13.873	1.52%	1.815	1.28%	0.183	0.56%	2741	14	2829	29	2677	9	-5.7%
TM_880	2.123	1.51%	5.009	1.22%	0.077	0.63%	1156	10	1173	13	1125	13	-4.3%
TM_1441	3.328	1.50%	3.767	1.30%	0.091	0.54%	1488	12	1518	18	1445	10	-5.0%
TM_1424	4.201	1.50%	3.314	1.31%	0.101	0.52%	1674	12	1700	20	1642	10	-3.5%
TM_1277	13.837	1.51%	1.859	1.35%	0.187	0.48%	2739	14	2774	30	2712	8	-2.3%
TM_912	16.364	1.41%	1.709	1.26%	0.203	0.43%	2898	13	2969	30	2849	7	-4.2%
TM_843	13.965	1.49%	1.825	1.34%	0.185	0.44%	2747	14	2816	30	2697	7	-4.4%
TM_2699	14.573	1.66%	1.779	1.19%	0.188	0.75%	2788	16	2875	28	2725	12	-5.5%
TM_2619	14.587	1.60%	1.791	1.12%	0.189	0.74%	2789	15	2860	26	2737	12	-4.5%
TM_2506	15.266	1.58%	1.694	1.00%	0.188	0.83%	2832	15	2991	24	2721	14	-9.9%
TM_2367	17.958	1.73%	1.619	1.25%	0.211	0.79%	2988	16	3101	31	2912	13	-6.5%
TM_2630	14.012	1.88%	1.871	1.45%	0.190	0.79%	2751	18	2760	32	2743	13	-0.6%
TM_2767	14.500	1.59%	1.806	1.09%	0.190	0.76%	2783	15	2840	25	2742	12	-3.6%
TM_2344	4.802	1.52%	3.143	0.97%	0.109	0.77%	1785	13	1781	15	1791	14	0.6%
TM_2438	13.947	1.60%	1.806	1.12%	0.183	0.74%	2746	15	2841	26	2677	12	-6.1%
TM_2332	2.914	1.43%	4.039	0.85%	0.085	0.75%	1385	11	1426	11	1324	14	-7.7%
TM_2568	12.265	2.03%	2.107	1.70%	0.187	0.71%	2625	19	2504	35	2720	12	8.0%
TM_2496	13.847	2.04%	1.865	1.70%	0.187	0.72%	2739	19	2767	38	2719	12	-1.8%
TM_2602	13.836	2.07%	1.831	1.75%	0.184	0.72%	2739	19	2810	40	2687	12	-4.6%
TM_2443	12.639	1.91%	1.999	1.55%	0.183	0.71%	2653	18	2615	33	2682	12	2.5%
TM_2652	13.423	2.10%	1.927	1.78%	0.188	0.70%	2710	20	2695	39	2721	12	1.0%
TM_2467	17.158	2.06%	1.654	1.74%	0.206	0.70%	2944	20	3048	42	2873	11	-6.1%
TM_2626	3.198	2.07%	3.843	1.68%	0.089	0.82%	1457	16	1491	22	1407	16	-5.9%
TM_2405	12.364	2.05%	2.099	1.73%	0.188	0.70%	2632	19	2512	36	2727	12	7.9%
TM_1860	14.043	2.86%	1.78	1.68%	0.181	1.43%	2753	27	2874	39	2664	23	-7.9%
TM_2028	14.561	2.88%	1.765	1.69%	0.186	1.46%	2787	27	2894	39	2711	24	-6.8%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
TM_2190	13.987	2.85%	1.818	1.66%	0.184	1.44%	2749	27	2825	38	2693	24	-4.9%
TM_2077	12.978	3.08%	2.039	2.03%	0.192	1.43%	2678	29	2573	43	2759	23	6.7%
TM_2031	13.950	2.78%	1.789	1.54%	0.181	1.43%	2746	26	2862	36	2662	24	-7.5%
TM_2109	12.306	3.06%	2.055	1.97%	0.183	1.46%	2628	28	2556	41	2684	24	4.8%
TM_1502	2.889	3.04%	4.233	1.58%	0.089	1.66%	1379	23	1367	19	1397	32	2.2%
TM_1621	3.056	3.40%	4.243	1.55%	0.094	2.16%	1422	26	1364	19	1509	40	9.6%
TM_1511	12.672	2.75%	1.961	1.17%	0.180	1.55%	2656	26	2657	25	2655	25	-0.1%
TM_1342	13.270	2.98%	1.943	1.59%	0.187	1.58%	2699	28	2676	35	2716	26	1.5%
TM_1359	4.033	3.04%	3.357	1.68%	0.098	1.60%	1641	24	1681	25	1590	30	-5.7%
TM_1241	3.176	2.92%	3.877	1.44%	0.089	1.60%	1451	22	1479	19	1411	30	-4.8%
							>10% Discordant						
TM_94	40.866	3.10%	1.843	1.81%	0.546	1.55%	3792	30	2794	41	4371	22	36.1%
TM_54	1.576	3.11%	6.962	1.80%	0.080	1.58%	961	19	865	15	1187	31	27.1%
TM_88	4.037	3.49%	7.829	3.33%	0.229	0.68%	1642	28	775	24	3047	11	74.6%
TM_772	9.371	2.37%	2.754	2.21%	0.187	0.54%	2375	21	1997	38	2718	9	26.5%
TM_419	19.427	3.55%	2.431	3.21%	0.342	1.22%	3063	34	2221	60	3674	18	39.5%
TM_402	10.153	1.67%	2.554	1.49%	0.188	0.52%	2449	15	2130	27	2725	8	21.8%
TM_497	3.974	1.44%	3.675	1.22%	0.106	0.52%	1629	12	1551	17	1731	10	10.4%
TM_484	3.044	2.98%	9.407	2.89%	0.208	0.48%	1419	23	651	18	2887	8	77.4%
TM_767	1.494	1.41%	13.398	1.20%	0.145	0.51%	928	9	464	5	2289	9	79.7%
TM_670	11.026	1.95%	2.346	1.80%	0.188	0.50%	2525	18	2289	35	2721	8	15.9%
TM_499	7.960	3.24%	3.172	3.19%	0.183	0.36%	2227	29	1767	49	2681	6	34.1%
TM_306	2.909	1.96%	4.564	1.68%	0.096	0.82%	1384	15	1277	19	1553	15	17.8%
TM_640	2.148	1.44%	10.543	1.19%	0.164	0.53%	1164	10	584	7	2500	9	76.6%
TM_790	4.925	1.56%	7.955	1.34%	0.284	0.52%	1807	13	763	10	3386	8	77.5%
TM_2004	1.988	1.54%	9.342	1.38%	0.135	0.46%	1111	10	656	9	2160	8	69.7%
TM_1102	2.476	2.77%	4.955	2.62%	0.089	0.68%	1265	20	1185	28	1403	13	15.5%
TM_886	2.830	1.57%	4.465	1.40%	0.092	0.52%	1363	12	1303	16	1460	10	10.7%
TM_655	0.501	1.42%	84.602	1.27%	0.308	0.43%	413	5	76	1	3509	7	97.8%
TM_605	9.148	2.12%	2.861	2.02%	0.190	0.43%	2353	19	1932	34	2741	7	29.5%
TM_2511	8.384	1.90%	3.084	1.52%	0.188	0.73%	2273	17	1810	24	2721	12	33.5%
TM_2469	8.765	2.74%	2.884	2.50%	0.183	0.70%	2314	25	1919	41	2683	12	28.5%
TM_2578	1.283	18.03%	21.034	17.87%	0.196	0.74%	838	98	299	52	2791	12	89.3%
TM_1730	1.473	2.77%	14.001	1.54%	0.150	1.42%	919	17	445	7	2341	24	81.0%
TM_1768	1.462	3.04%	10.373	1.96%	0.110	1.43%	915	18	593	11	1799	26	67.0%
TM_1921	1.873	3.30%	7.283	2.33%	0.099	1.45%	1072	22	829	18	1604	27	48.3%
TM_1789	2.946	2.90%	3.941	1.72%	0.084	1.45%	1394	22	1458	22	1298	28	-12.3%
TM_1603	2.200	3.01%	6.251	1.57%	0.100	1.64%	1181	21	957	14	1619	30	40.9%
TM_1675	8.251	3.41%	3.156	2.30%	0.189	1.56%	2259	30	1774	36	2732	25	35.1%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
TM_1464	3.724	2.86%	3.82	1.37%	0.103	1.57%	1577	23	1499	18	1682	29	10.9%
TM_1346	1.719	3.18%	15.406	1.95%	0.192	1.56%	1016	20	405	8	2760	25	85.3%

APPENDIX J

Data Tables for Sample BT –

Lower Basal Tulip Creek Sandstone,

Tulip Creek Formation, Simpson Group

Sample BT - Lower Basal Tulip Creek Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
BT_426	13.253	1.58%	1.953	1.38%	0.188	0.52%	2698	15	2666	30	2722	9	2.1%
BT_364	2.165	1.54%	5.088	1.32%	0.080	0.55%	1170	11	1157	14	1194	11	3.1%
BT_332	1.781	1.54%	5.769	1.27%	0.075	0.62%	1038	10	1031	12	1055	13	2.3%
BT_209	1.767	1.55%	5.789	1.30%	0.074	0.59%	1033	10	1027	12	1047	12	1.9%
BT_142	12.589	1.60%	2.032	1.40%	0.186	0.53%	2649	15	2580	30	2703	9	4.6%
BT_169	33.363	1.48%	1.350	1.31%	0.327	0.44%	3591	14	3573	36	3602	7	0.8%
BT_87	13.033	1.54%	1.961	1.34%	0.185	0.51%	2682	14	2656	29	2702	8	1.7%
BT_2	1.856	1.54%	5.599	1.31%	0.075	0.57%	1066	10	1059	13	1079	11	1.8%
BT_3	14.990	1.47%	1.847	1.29%	0.201	0.46%	2815	14	2790	29	2832	7	1.5%
BT_9	12.844	1.51%	1.964	1.31%	0.183	0.50%	2668	14	2653	28	2680	8	1.0%
BT_8	1.791	1.53%	5.782	1.31%	0.075	0.56%	1042	10	1028	12	1071	11	4.0%
BT_98	4.988	1.52%	3.077	0.80%	0.111	0.85%	1817	13	1814	13	1821	15	0.4%
BT_155	2.140	1.50%	5.132	0.72%	0.080	0.87%	1162	10	1148	8	1189	17	3.5%
BT_277	12.915	1.41%	1.955	0.69%	0.183	0.77%	2673	13	2663	15	2682	13	0.7%
BT_275	13.185	1.38%	1.951	0.65%	0.187	0.76%	2693	13	2667	14	2712	12	1.7%
BT_326	1.801	1.70%	5.772	0.90%	0.075	1.01%	1046	11	1030	9	1079	20	4.5%
BT_320	12.501	1.37%	1.985	0.63%	0.180	0.76%	2643	13	2630	14	2653	13	0.9%
BT_425	14.769	1.42%	1.848	0.70%	0.198	0.78%	2800	13	2788	16	2809	13	0.8%
BT_497	13.046	1.38%	1.943	0.64%	0.184	0.76%	2683	13	2676	14	2688	13	0.5%
BT_385	13.298	1.43%	1.952	0.71%	0.188	0.78%	2701	13	2667	15	2727	13	2.2%
BT_537	17.377	1.45%	1.736	0.77%	0.219	0.78%	2956	14	2933	18	2972	12	1.3%
BT_544	18.751	1.37%	1.669	0.63%	0.227	0.75%	3029	13	3027	15	3031	12	0.1%
BT_291	12.717	2.67%	1.993	2.30%	0.184	0.81%	2659	25	2621	49	2688	13	2.5%
BT_256	12.379	2.63%	2.006	2.27%	0.180	0.80%	2634	24	2607	48	2654	13	1.8%
BT_327	12.894	2.66%	1.999	2.29%	0.187	0.81%	2672	25	2615	49	2715	13	3.7%
BT_272	12.532	2.65%	2.028	2.28%	0.184	0.81%	2645	25	2584	48	2692	13	4.0%
BT_282	12.469	2.63%	2.009	2.26%	0.182	0.81%	2640	24	2604	48	2668	13	2.4%
BT_288	12.742	2.68%	2.011	2.30%	0.186	0.84%	2661	25	2602	49	2706	14	3.8%
BT_224	12.922	2.66%	1.981	2.28%	0.186	0.84%	2674	25	2635	49	2704	14	2.6%
BT_121	14.213	2.64%	1.911	2.27%	0.197	0.81%	2764	25	2713	50	2801	13	3.1%
BT_32	12.877	2.68%	1.979	2.30%	0.185	0.83%	2671	25	2636	50	2697	14	2.2%
BT_461	12.773	3.31%	1.990	3.05%	0.184	0.79%	2663	31	2625	65	2692	13	2.5%
BT_777	12.640	3.31%	2.018	3.05%	0.185	0.81%	2653	31	2595	65	2698	13	3.8%
BT_750	3.051	3.30%	4.098	3.02%	0.091	0.86%	1420	25	1407	38	1440	16	2.2%
BT_700	2.622	3.27%	4.491	3.01%	0.085	0.79%	1307	24	1296	35	1324	15	2.1%
BT_472	2.089	3.27%	5.194	3.01%	0.079	0.79%	1145	22	1135	31	1164	16	2.5%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
BT_304	14.229	3.28%	1.918	3.04%	0.198	0.75%	2765	31	2706	67	2809	12	3.7%
BT_360	12.747	3.32%	2.010	3.07%	0.186	0.80%	2661	31	2603	65	2705	13	3.8%
BT_1295	12.906	1.93%	1.989	1.65%	0.186	0.64%	2673	18	2626	35	2709	11	3.1%
BT_1172	1.840	1.89%	5.666	1.59%	0.076	0.66%	1060	12	1048	15	1085	13	3.4%
BT_996	2.160	2.84%	4.946	2.09%	0.077	1.54%	1168	19	1187	23	1133	30	-4.8%
BT_870	1.790	1.98%	5.742	1.66%	0.075	0.73%	1042	13	1035	16	1057	15	2.1%
BT_932	2.060	1.98%	5.316	1.62%	0.079	0.78%	1136	13	1111	17	1182	15	6.0%
BT_939	13.015	1.90%	1.953	1.63%	0.184	0.62%	2681	18	2666	35	2692	10	1.0%
BT_882	1.845	1.95%	5.648	1.64%	0.076	0.70%	1062	13	1051	16	1084	14	3.1%
BT_724	10.355	1.92%	2.227	1.63%	0.167	0.66%	2467	18	2391	32	2531	11	5.5%
BT_659	11.998	1.90%	2.139	1.63%	0.186	0.61%	2604	18	2473	33	2708	10	8.7%
BT_1473	13.241	3.03%	1.933	2.86%	0.186	0.62%	2697	28	2688	62	2704	10	0.6%
BT_1581	3.097	3.04%	4.060	2.86%	0.091	0.65%	1432	23	1419	36	1451	12	2.2%
BT_1741	2.339	3.21%	4.977	3.02%	0.084	0.70%	1224	23	1180	32	1303	14	9.4%
BT_1747	13.814	3.01%	1.880	2.84%	0.188	0.61%	2737	28	2749	63	2728	10	-0.8%
BT_1750	13.284	3.03%	1.912	2.86%	0.184	0.61%	2700	28	2712	63	2691	10	-0.8%
BT_1787	1.837	3.04%	5.627	2.85%	0.075	0.66%	1059	20	1055	28	1068	13	1.3%
BT_1697	3.093	3.03%	4.073	2.85%	0.091	0.63%	1431	23	1415	36	1455	12	2.7%
BT_1502	1.822	3.05%	5.647	2.85%	0.075	0.69%	1053	20	1051	28	1058	14	0.7%
BT_1142	12.429	2.94%	2.022	2.72%	0.182	0.66%	2637	27	2591	58	2674	11	3.1%
BT_1206	12.627	2.95%	1.975	2.74%	0.181	0.65%	2652	27	2641	59	2661	11	0.7%
BT_1339	12.541	3.05%	2.053	2.84%	0.187	0.68%	2646	28	2558	60	2714	11	5.7%
BT_1425	13.010	2.97%	1.988	2.75%	0.188	0.67%	2680	28	2627	59	2721	11	3.5%
BT_1500	12.670	2.95%	2.001	2.74%	0.184	0.66%	2655	27	2612	58	2688	11	2.8%
BT_1516	13.302	3.00%	1.942	2.77%	0.187	0.69%	2701	28	2678	61	2719	11	1.5%
BT_1481	1.839	3.00%	5.628	2.75%	0.075	0.76%	1059	20	1054	27	1070	15	1.5%
BT_1493	12.414	2.97%	2.049	2.75%	0.185	0.67%	2636	28	2562	58	2694	11	4.9%
BT_1393	1.892	2.99%	5.534	2.74%	0.076	0.77%	1078	20	1071	27	1094	15	2.1%
BT_683	14.741	2.13%	1.847	1.45%	0.197	0.98%	2799	20	2790	33	2805	16	0.5%
BT_686	3.071	2.09%	4.039	1.39%	0.090	0.99%	1426	16	1426	18	1425	19	-0.1%
BT_735	5.973	2.07%	2.774	1.39%	0.120	0.95%	1972	18	1985	24	1958	17	-1.4%
BT_816	1.887	2.12%	5.474	1.40%	0.075	1.02%	1076	14	1082	14	1066	20	-1.5%
BT_890	12.928	2.09%	1.968	1.41%	0.185	0.97%	2674	20	2649	30	2694	16	1.7%
BT_1063	12.818	2.11%	1.977	1.43%	0.184	0.98%	2666	20	2639	31	2687	16	1.8%
BT_1004	13.362	2.04%	1.915	1.35%	0.186	0.95%	2706	19	2709	30	2703	16	-0.2%
BT_915	2.091	2.13%	5.093	1.40%	0.077	1.04%	1146	15	1156	15	1127	21	-2.5%
BT_989	12.064	2.07%	2.065	1.39%	0.181	0.95%	2609	19	2546	29	2659	16	4.2%
BT_1006	2.083	3.14%	5.118	2.40%	0.077	1.25%	1143	21	1150	25	1130	25	-1.8%
BT_879	12.929	3.07%	1.930	2.37%	0.181	1.17%	2674	29	2691	52	2662	19	-1.1%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
BT_824	13.345	3.09%	1.920	2.38%	0.186	1.18%	2704	29	2702	52	2706	19	0.1%
BT_699	2.046	3.09%	5.204	2.38%	0.077	1.20%	1131	21	1133	25	1127	24	-0.5%
BT_599	2.032	3.15%	5.179	2.41%	0.076	1.27%	1126	21	1138	25	1104	25	-3.1%
BT_712	12.614	3.09%	1.972	2.38%	0.180	1.18%	2651	29	2644	51	2656	19	0.5%
BT_736	12.679	3.10%	1.980	2.40%	0.182	1.18%	2656	29	2635	52	2672	19	1.4%
BT_1597	11.952	3.44%	2.043	2.75%	0.177	1.24%	2601	32	2568	58	2626	20	2.2%
BT_1435	2.041	3.52%	5.182	2.77%	0.077	1.34%	1129	24	1138	29	1113	27	-2.2%
BT_1431	13.366	3.44%	1.917	2.74%	0.186	1.24%	2706	32	2706	60	2706	20	0.0%
BT_1312	12.898	3.46%	1.992	2.76%	0.186	1.25%	2672	32	2622	59	2710	20	3.2%
BT_1279	12.701	3.44%	1.959	2.74%	0.180	1.23%	2658	32	2659	59	2657	20	-0.1%
BT_1141	13.004	3.44%	1.943	2.75%	0.183	1.23%	2680	32	2677	60	2683	20	0.2%
BT_1082	12.011	3.51%	2.073	2.80%	0.181	1.29%	2605	32	2538	58	2658	21	4.5%
BT_944	12.642	3.46%	1.968	2.76%	0.180	1.25%	2653	32	2649	60	2657	21	0.3%
BT_819	12.690	3.03%	1.953	2.01%	0.180	1.38%	2657	28	2665	44	2651	23	-0.5%
BT_1241	12.912	3.04%	1.952	2.02%	0.183	1.39%	2673	28	2666	44	2679	23	0.5%
BT_1338	12.753	3.13%	1.990	2.12%	0.184	1.43%	2662	29	2624	46	2690	23	2.5%
BT_1438	12.882	3.01%	1.970	1.99%	0.184	1.38%	2671	28	2646	43	2690	23	1.6%
BT_1403	12.663	3.06%	1.995	2.04%	0.183	1.40%	2655	28	2619	44	2682	23	2.3%
BT_1373	12.777	3.03%	1.977	2.01%	0.183	1.39%	2663	28	2638	43	2683	23	1.7%
BT_1232	4.920	3.03%	3.104	2.00%	0.111	1.40%	1806	25	1800	31	1812	25	0.6%
BT_1117	4.937	3.07%	3.100	2.04%	0.111	1.43%	1809	26	1803	32	1816	26	0.7%
BT_1412	18.554	3.03%	1.689	2.02%	0.227	1.38%	3019	29	2998	48	3033	22	1.2%
							>10% Discordant						
BT_330	1.054	2.70%	19.873	2.27%	0.152	0.95%	731	14	316	7	2368	16	86.6%
BT_112	10.529	2.63%	2.982	2.26%	0.228	0.80%	2482	24	1864	37	3036	13	38.6%
BT_811	3.319	3.33%	7.728	3.09%	0.186	0.73%	1486	26	784	23	2707	12	71.0%
BT_702	1.723	3.27%	6.096	3.02%	0.076	0.79%	1017	21	979	27	1099	16	10.9%
BT_507	5.327	3.35%	4.875	3.11%	0.188	0.74%	1873	28	1203	34	2728	12	55.9%
BT_370	3.090	3.34%	4.379	3.04%	0.098	0.91%	1430	25	1326	36	1589	17	16.6%
BT_862	2.398	3.37%	10.469	3.21%	0.182	0.62%	1242	24	588	18	2672	10	78.0%
BT_759	1.492	1.98%	7.900	1.71%	0.085	0.65%	927	12	768	12	1326	12	42.1%
BT_1496	10.611	3.08%	2.432	2.92%	0.187	0.60%	2490	28	2220	55	2718	10	18.3%
BT_1695	2.497	3.35%	5.183	3.15%	0.094	0.74%	1271	24	1137	33	1506	14	24.5%
BT_1447	9.761	3.05%	2.518	2.84%	0.178	0.66%	2412	28	2156	52	2637	11	18.2%
BT_709	1.796	2.05%	6.005	1.35%	0.078	0.97%	1044	13	993	12	1153	19	13.9%
BT_1035	10.851	3.11%	2.322	2.40%	0.183	1.20%	2510	28	2309	46	2678	20	13.8%
BT_990	8.485	3.30%	2.917	2.65%	0.180	1.17%	2284	30	1900	43	2648	19	28.2%
BT_692	10.815	3.09%	2.349	2.39%	0.184	1.17%	2507	28	2286	46	2692	19	15.1%
BT_1532	4.156	3.51%	6.409	2.83%	0.193	1.23%	1665	28	935	25	2769	20	66.3%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
BT_1596	7.403	3.51%	3.988	2.83%	0.214	1.25%	2161	31	1442	36	2937	20	50.9%
BT_1281	2.418	3.36%	5.397	2.11%	0.095	1.79%	1248	24	1096	21	1521	33	28.0%

APPENDIX K

Data Tables for Sample TCT –

Upper Basal Tulip Creek Sandstone,

Tulip Creek Formation, Simpson Group

Sample TCT - Upper Basal Tulip Creek Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
TCT_82	13.714	1.09%	1.882	1.02%	0.187	0.40%	2730	10	2747	23	2718	7	-1.0%
TCT_64	13.190	1.04%	1.902	0.98%	0.182	0.39%	2693	10	2723	22	2671	6	-2.0%
TCT_33	13.317	1.18%	1.884	1.12%	0.182	0.40%	2702	11	2745	25	2671	7	-2.8%
TCT_6	14.015	1.25%	1.825	1.19%	0.185	0.38%	2751	12	2817	27	2702	6	-4.3%
TCT_19	13.806	0.97%	1.873	0.91%	0.187	0.36%	2736	9	2758	20	2720	6	-1.4%
TCT_34	21.839	1.03%	1.568	0.98%	0.248	0.31%	3177	10	3180	25	3174	5	-0.2%
TCT_25	3.436	1.33%	3.774	1.19%	0.094	0.67%	1513	10	1515	16	1510	13	-0.4%
TCT_4	11.872	1.46%	2.159	1.39%	0.186	0.46%	2594	14	2454	28	2706	8	9.3%
TCT_1	13.416	1.06%	1.897	1.01%	0.185	0.34%	2709	10	2730	22	2694	6	-1.3%
TCT_276	13.401	1.46%	1.907	1.21%	0.185	0.71%	2708	14	2717	27	2702	12	-0.6%
TCT_259	1.906	1.73%	5.403	1.39%	0.075	1.01%	1083	11	1095	14	1060	20	-3.3%
TCT_220	2.119	1.63%	5.089	1.27%	0.078	1.00%	1155	11	1156	13	1153	20	-0.3%
TCT_116	5.649	1.38%	2.811	1.10%	0.115	0.75%	1924	12	1962	19	1883	13	-4.2%
TCT_161	13.437	1.61%	1.881	1.37%	0.183	0.75%	2711	15	2749	31	2683	12	-2.5%
TCT_80	13.487	2.09%	1.930	1.90%	0.189	0.78%	2714	20	2691	42	2732	13	1.5%
TCT_81	13.284	1.52%	1.921	1.28%	0.185	0.72%	2700	14	2702	28	2699	12	-0.1%
TCT_109	16.325	1.58%	1.760	1.35%	0.208	0.73%	2896	15	2901	31	2893	12	-0.3%
TCT_177	1.843	1.05%	5.555	0.72%	0.074	0.71%	1061	7	1067	7	1049	14	-1.7%
TCT_164	12.636	1.19%	1.961	0.94%	0.180	0.65%	2653	11	2657	21	2650	11	-0.3%
TCT_133	1.959	1.13%	5.384	0.79%	0.076	0.77%	1102	8	1098	8	1108	15	0.9%
TCT_147	13.089	1.04%	1.926	0.77%	0.183	0.61%	2686	10	2696	17	2679	10	-0.6%
TCT_155	13.499	1.41%	1.882	1.19%	0.184	0.69%	2715	13	2747	26	2691	11	-2.1%
TCT_162	2.010	1.94%	5.318	1.60%	0.078	1.15%	1119	13	1111	16	1134	23	2.1%
TCT_159	13.591	1.71%	1.890	1.54%	0.186	0.67%	2722	16	2738	34	2710	11	-1.0%
TCT_131	1.869	1.50%	5.604	1.15%	0.076	0.98%	1070	10	1059	11	1094	20	3.2%
TCT_139	14.051	1.75%	1.874	1.57%	0.191	0.73%	2753	16	2757	35	2750	12	-0.3%
TCT_87	13.940	2.66%	1.825	2.52%	0.185	0.79%	2746	25	2817	57	2694	13	-4.6%
TCT_97	1.897	1.16%	5.461	0.84%	0.075	0.75%	1080	8	1084	8	1072	15	-1.1%
TCT_150	2.018	1.80%	5.188	1.65%	0.076	0.79%	1121	12	1136	17	1093	16	-4.0%
TCT_145	14.008	1.62%	1.846	1.54%	0.188	0.50%	2750	15	2790	35	2721	8	-2.5%
TCT_105	13.233	1.64%	1.903	1.56%	0.183	0.49%	2696	15	2722	35	2677	8	-1.7%
TCT_108	13.764	2.60%	1.861	2.54%	0.186	0.61%	2734	24	2772	57	2705	10	-2.5%
TCT_70	15.193	2.85%	1.734	2.77%	0.191	0.66%	2827	27	2935	65	2752	11	-6.7%
TCT_61	13.534	1.54%	2.005	1.47%	0.197	0.44%	2718	14	2609	31	2800	7	6.8%
TCT_7	2.554	1.62%	4.602	1.51%	0.085	0.63%	1288	12	1268	17	1321	12	4.1%
TCT_32	15.120	1.87%	1.791	1.79%	0.196	0.53%	2823	18	2859	41	2797	9	-2.2%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
TCT_107	5.455	1.56%	2.923	1.46%	0.116	0.57%	1894	13	1897	24	1890	10	-0.4%
TCT_285	12.532	1.40%	1.971	1.37%	0.179	0.36%	2645	13	2646	30	2645	6	0.0%
TCT_263	12.748	1.35%	2.021	1.32%	0.187	0.32%	2661	13	2592	28	2714	5	4.5%
TCT_246	13.790	1.34%	1.865	1.30%	0.186	0.34%	2735	13	2768	29	2711	6	-2.1%
TCT_250	5.540	1.40%	2.889	1.35%	0.116	0.42%	1907	12	1916	22	1896	7	-1.1%
TCT_199	1.900	1.38%	5.416	1.28%	0.075	0.58%	1081	9	1092	13	1059	12	-3.2%
TCT_178	15.270	1.51%	1.831	1.35%	0.203	0.76%	2832	14	2809	31	2849	12	1.4%
TCT_99	13.200	1.65%	1.906	1.59%	0.182	0.48%	2694	15	2719	35	2675	8	-1.7%
TCT_35	13.884	1.37%	1.851	1.33%	0.186	0.32%	2742	13	2785	30	2710	5	-2.8%
TCT_58	14.819	1.27%	1.790	1.22%	0.192	0.39%	2804	12	2860	28	2763	6	-3.5%
TCT_122	14.109	1.59%	1.846	1.54%	0.189	0.42%	2757	15	2791	35	2733	7	-2.1%
TCT_134	5.661	1.43%	2.832	1.36%	0.116	0.50%	1926	12	1950	23	1900	9	-2.6%
TCT_412	13.802	1.97%	1.864	1.82%	0.187	0.65%	2736	18	2769	41	2712	11	-2.1%
TCT_395	13.281	2.79%	1.881	2.65%	0.181	0.77%	2700	26	2749	59	2663	13	-3.2%
TCT_341	12.357	2.05%	2.035	1.90%	0.182	0.67%	2632	19	2577	40	2674	11	3.6%
TCT_401	12.944	2.02%	1.929	1.87%	0.181	0.67%	2676	19	2692	41	2663	11	-1.1%
TCT_319	2.249	2.01%	4.847	1.83%	0.079	0.77%	1196	14	1209	20	1173	15	-3.0%
TCT_308	13.548	2.39%	1.884	2.25%	0.185	0.73%	2719	22	2745	50	2699	12	-1.7%
TCT_330	1.731	2.04%	5.763	1.84%	0.072	0.82%	1020	13	1031	18	995	17	-3.6%
TCT_328	14.120	2.03%	1.837	1.88%	0.188	0.67%	2758	19	2802	43	2726	11	-2.8%
TCT_309	3.377	2.14%	3.827	1.96%	0.094	0.79%	1499	17	1497	26	1502	15	0.4%
TCT_451	5.976	2.04%	2.749	1.02%	0.119	1.53%	1972	18	2000	18	1943	27	-2.9%
TCT_398	13.184	2.27%	1.936	1.44%	0.185	1.51%	2693	21	2684	32	2699	25	0.6%
TCT_490	13.934	2.47%	1.844	1.73%	0.186	1.53%	2745	23	2793	39	2710	25	-3.1%
TCT_538	4.236	1.99%	3.424	0.93%	0.105	1.51%	1681	16	1652	14	1718	28	3.8%
TCT_489	13.617	2.02%	1.885	1.02%	0.186	1.51%	2723	19	2744	23	2708	25	-1.3%
TCT_478	13.305	2.05%	1.892	1.07%	0.183	1.50%	2702	19	2735	24	2676	25	-2.2%
TCT_511b	13.256	2.02%	1.894	1.04%	0.182	1.49%	2698	19	2733	23	2672	24	-2.3%
TCT_511a	1.857	2.08%	5.662	1.04%	0.076	1.59%	1066	14	1048	10	1101	32	4.8%
TCT_781	12.809	1.12%	1.962	1.09%	0.182	0.34%	2666	10	2655	24	2674	6	0.7%
TCT_794	14.438	1.35%	1.808	1.30%	0.189	0.46%	2779	13	2838	30	2736	8	-3.7%
TCT_741	13.555	0.82%	1.880	0.79%	0.185	0.32%	2719	8	2749	18	2697	5	-1.9%
TCT_713	14.026	1.49%	1.840	1.45%	0.187	0.47%	2751	14	2798	33	2718	8	-2.9%
TCT_640	15.801	1.11%	1.724	1.02%	0.198	0.55%	2865	11	2949	24	2806	9	-5.1%
TCT_621	5.307	1.05%	2.990	0.98%	0.115	0.50%	1870	9	1860	16	1881	9	1.1%
TCT_571	13.531	0.92%	1.914	0.89%	0.188	0.31%	2717	9	2709	20	2723	5	0.5%
TCT_488	8.284	1.21%	2.540	0.92%	0.153	0.94%	2263	11	2140	17	2375	16	9.9%
TCT_445b	2.213	1.17%	5.030	1.04%	0.081	0.67%	1185	8	1169	11	1215	13	3.8%
TCT_445a	13.739	0.93%	1.889	0.89%	0.188	0.34%	2732	9	2738	20	2727	6	-0.4%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
TCT_862	1.726	2.53%	5.879	2.24%	0.074	1.10%	1018	16	1013	21	1030	22	1.7%
TCT_898	1.903	2.84%	5.460	2.52%	0.075	1.27%	1082	19	1084	25	1078	25	-0.6%
TCT_867	13.266	2.29%	1.962	2.09%	0.189	0.76%	2699	21	2655	45	2732	12	2.8%
TCT_875	2.689	2.28%	4.444	2.07%	0.087	0.80%	1325	17	1308	24	1353	15	3.3%
TCT_897	6.197	2.61%	2.819	2.20%	0.127	1.41%	2004	23	1957	37	2053	25	4.7%
TCT_843	16.239	2.48%	1.797	2.29%	0.212	0.78%	2891	23	2852	53	2918	13	2.2%
TCT_699	1.942	2.26%	5.533	2.01%	0.078	0.93%	1096	15	1071	20	1145	18	6.4%
TCT_685	13.114	2.20%	1.946	2.01%	0.185	0.72%	2688	21	2673	44	2699	12	1.0%
TCT_710	13.149	2.37%	1.946	2.19%	0.186	0.76%	2690	22	2673	48	2703	13	1.1%
TCT_864	13.181	2.14%	1.948	2.05%	0.186	0.47%	2693	20	2671	45	2709	8	1.4%
TCT_837	1.912	2.61%	5.462	2.39%	0.076	1.06%	1085	17	1084	24	1089	21	0.4%
TCT_906	13.599	2.14%	1.878	2.05%	0.185	0.48%	2722	20	2752	46	2700	8	-1.9%
TCT_884	13.330	2.11%	1.906	2.03%	0.184	0.47%	2703	20	2719	45	2691	8	-1.0%
TCT_857	2.647	2.19%	4.376	2.07%	0.084	0.70%	1314	16	1327	25	1293	13	-2.7%
TCT_900	13.248	2.17%	1.923	2.09%	0.185	0.49%	2698	20	2699	46	2697	8	-0.1%
TCT_902	12.912	2.16%	1.944	2.08%	0.182	0.48%	2673	20	2675	45	2672	8	-0.1%
TCT_880	12.895	2.36%	1.969	2.27%	0.184	0.56%	2672	22	2648	49	2690	9	1.6%
TCT_885	13.059	2.16%	1.922	2.08%	0.182	0.47%	2684	20	2700	46	2672	8	-1.1%
TCT_853	13.243	2.53%	1.936	2.44%	0.186	0.55%	2697	24	2685	53	2706	9	0.8%
TCT_722	13.338	2.44%	1.924	2.30%	0.186	0.66%	2704	23	2698	51	2708	11	0.4%
TCT_882	2.657	2.45%	4.495	2.28%	0.087	0.81%	1316	18	1295	27	1352	16	4.2%
TCT_588	12.736	2.50%	1.984	2.36%	0.183	0.71%	2660	23	2632	51	2682	12	1.9%
TCT_545	13.792	3.12%	1.832	2.99%	0.183	0.76%	2736	29	2808	68	2683	13	-4.7%
TCT_557	12.658	2.69%	1.975	2.56%	0.181	0.72%	2655	25	2641	55	2665	12	0.9%
TCT_629	5.485	2.38%	2.904	2.23%	0.116	0.71%	1898	20	1908	37	1888	13	-1.1%
TCT_637	13.108	2.36%	1.945	2.23%	0.185	0.65%	2687	22	2674	49	2698	11	0.9%
TCT_628	13.113	2.34%	1.951	2.21%	0.186	0.63%	2688	22	2667	48	2704	10	1.3%
TCT_725	4.820	2.39%	3.166	2.24%	0.111	0.75%	1788	20	1769	35	1811	14	2.3%
TCT_772	2.195	2.30%	5.175	2.15%	0.082	0.70%	1179	16	1139	22	1255	14	9.2%
							>10% Discordant						
TCT_18	10.397	0.85%	2.801	0.79%	0.211	0.33%	2471	8	1968	13	2915	5	32.5%
TCT_67	3.518	1.53%	8.010	1.28%	0.204	0.75%	1531	12	758	9	2862	12	73.5%
TCT_73	5.452	1.54%	4.631	1.27%	0.183	0.79%	1893	13	1260	15	2681	13	53.0%
TCT_88	1.985	1.79%	5.937	1.65%	0.085	0.75%	1110	12	1003	15	1326	15	24.4%
TCT_529	2.205	4.72%	11.917	4.37%	0.191	1.53%	1183	32	519	22	2747	25	81.1%
TCT_502	17.207	2.16%	1.566	1.21%	0.195	1.56%	2946	20	3183	30	2789	25	-14.1%
TCT_888	0.204	5.05%	127.047	4.93%	0.188	0.78%	188	9	51	2	2722	13	98.1%

APPENDIX L

Data Tables for Sample S5 –

Lower St. Peter Sandstone,

St. Peter Formation

Sample S5 - Lower St. Peter Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
S5_47	13.515	1.63%	1.910	1.54%	0.187	0.51%	2716	15	2714	34	2718	8	0.1%
S5_33	13.439	1.60%	1.914	1.52%	0.187	0.46%	2711	15	2710	34	2712	8	0.1%
S5_34	13.716	3.62%	1.942	3.51%	0.193	0.96%	2730	34	2677	76	2770	16	3.3%
S5_46	2.254	2.09%	4.876	1.98%	0.080	0.70%	1198	15	1203	22	1190	14	-1.0%
S5_26	1.841	2.01%	5.699	1.86%	0.076	0.79%	1060	13	1042	18	1097	16	5.0%
S5_21	13.101	1.66%	1.949	1.56%	0.185	0.54%	2687	16	2669	34	2700	9	1.1%
S5_1	1.897	1.73%	5.516	1.61%	0.076	0.65%	1080	11	1074	16	1092	13	1.7%
S5_11	1.885	1.81%	5.635	1.67%	0.077	0.71%	1076	12	1053	16	1122	14	6.1%
S5_15	5.165	1.99%	2.989	1.88%	0.112	0.68%	1847	17	1860	30	1832	12	-1.6%
S5_3	2.002	1.72%	5.263	1.59%	0.076	0.68%	1116	12	1121	16	1106	13	-1.4%
S5_138	2.489	2.37%	4.579	2.22%	0.083	0.92%	1269	17	1273	26	1261	18	-1.0%
S5_128	13.700	2.27%	1.874	2.20%	0.186	0.57%	2729	21	2757	49	2708	9	-1.8%
S5_115	14.651	2.99%	1.769	2.88%	0.188	0.87%	2793	28	2888	67	2725	14	-6.0%
S5_116	13.410	1.85%	1.892	1.79%	0.184	0.47%	2709	17	2735	40	2689	8	-1.7%
S5_41	13.725	1.90%	1.854	1.83%	0.185	0.51%	2731	18	2781	41	2694	8	-3.2%
S5_53	2.507	1.90%	4.615	1.76%	0.084	0.77%	1274	14	1264	20	1291	15	2.1%
S5_62	1.922	2.28%	5.460	2.12%	0.076	0.93%	1089	15	1084	21	1098	18	1.3%
S5_42	13.913	2.36%	1.859	2.30%	0.188	0.54%	2744	22	2775	52	2721	9	-2.0%
S5_10	1.904	2.34%	5.379	2.18%	0.074	0.92%	1083	15	1099	22	1049	19	-4.8%
S5_28	1.897	2.15%	5.495	2.02%	0.076	0.78%	1080	14	1078	20	1085	15	0.7%
S5_59	12.933	1.92%	1.928	1.86%	0.181	0.46%	2675	18	2693	41	2661	8	-1.2%
S5_333	14.720	1.64%	1.786	1.54%	0.191	0.59%	2797	15	2866	36	2748	10	-4.3%
S5_306	1.996	1.45%	5.305	1.35%	0.077	0.57%	1114	10	1113	14	1116	11	0.3%
S5_326	15.998	1.70%	1.685	1.63%	0.195	0.54%	2877	16	3004	39	2789	9	-7.7%
S5_409	2.031	1.98%	5.178	1.83%	0.076	0.82%	1126	13	1138	19	1102	16	-3.3%
S5_357	5.196	2.50%	2.939	2.38%	0.111	0.85%	1852	21	1888	39	1812	15	-4.2%
S5_352	14.621	2.33%	1.779	2.23%	0.189	0.75%	2791	22	2875	51	2730	12	-5.3%
S5_293	14.931	2.63%	1.759	2.51%	0.190	0.83%	2811	25	2902	58	2746	14	-5.7%
S5_132	14.059	1.87%	1.837	1.80%	0.187	0.56%	2754	18	2802	41	2718	9	-3.1%
S5_160	5.117	1.30%	3.001	1.20%	0.111	0.51%	1839	11	1854	19	1822	9	-1.8%
S5_157	13.052	2.98%	1.981	2.90%	0.188	0.70%	2683	28	2634	62	2721	11	3.2%
S5_546	1.832	3.37%	5.568	3.22%	0.074	1.08%	1057	22	1065	32	1041	22	-2.3%
S5_555	5.168	3.07%	2.929	2.96%	0.110	0.90%	1847	26	1893	48	1796	16	-5.4%
S5_442	2.909	2.39%	4.246	2.27%	0.090	0.80%	1384	18	1363	28	1417	15	3.8%
S5_416	1.895	2.70%	5.403	2.57%	0.074	0.93%	1079	18	1095	26	1048	19	-4.4%
S5_506	12.863	3.42%	1.961	3.33%	0.183	0.85%	2670	32	2657	72	2679	14	0.8%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
S5_474	13.352	2.63%	1.854	2.53%	0.180	0.80%	2705	25	2781	57	2649	13	-5.0%
S5_465	14.570	3.16%	1.786	3.05%	0.189	0.89%	2788	30	2867	70	2731	15	-5.0%
S5_350	17.180	1.67%	1.689	1.62%	0.210	0.42%	2945	16	2998	39	2909	7	-3.1%
S5_318	15.177	1.34%	1.809	1.29%	0.199	0.38%	2826	13	2836	30	2819	6	-0.6%
S5_422	17.701	3.06%	1.628	2.95%	0.209	0.87%	2974	29	3087	72	2898	14	-6.5%
S5_82	13.171	3.06%	1.936	2.96%	0.185	0.77%	2692	28	2685	65	2697	13	0.5%
S5_57	13.301	2.03%	1.896	1.93%	0.183	0.59%	2701	19	2730	43	2679	10	-1.9%
S5_91	15.272	2.25%	1.801	2.15%	0.199	0.62%	2832	21	2848	49	2821	10	-0.9%
S5_65	15.417	2.42%	1.762	2.32%	0.197	0.66%	2841	23	2898	54	2802	11	-3.4%
S5_40	13.506	2.06%	1.888	1.96%	0.185	0.59%	2716	19	2740	44	2698	10	-1.6%
S5_44	13.944	3.30%	1.876	3.21%	0.190	0.78%	2746	31	2754	72	2740	13	-0.5%
S5_31	5.133	2.09%	3.041	1.99%	0.113	0.58%	1842	18	1833	32	1852	11	1.0%
S5_12	13.315	2.12%	1.913	2.02%	0.185	0.59%	2702	20	2711	45	2696	10	-0.6%
S5_640	1.978	3.14%	5.289	2.99%	0.076	1.02%	1108	21	1116	31	1092	20	-2.2%
S5_561	1.836	3.43%	5.586	3.25%	0.074	1.16%	1058	22	1062	32	1051	23	-1.0%
S5_341	13.806	1.68%	1.891	1.58%	0.189	0.57%	2736	16	2737	35	2736	9	0.0%
S5_278	14.124	1.37%	1.866	1.27%	0.191	0.48%	2758	13	2767	29	2752	8	-0.5%
S5_284	1.940	1.60%	5.465	1.45%	0.077	0.69%	1095	11	1083	14	1119	14	3.2%
S5_108	13.402	1.67%	1.914	1.58%	0.186	0.52%	2708	16	2710	35	2707	9	-0.1%
S5_106	1.907	1.94%	5.461	1.72%	0.076	0.97%	1083	13	1084	17	1082	19	-0.1%
S5_312	13.324	1.75%	1.885	1.69%	0.182	0.49%	2703	16	2744	38	2672	8	-2.7%
S5_316	13.673	1.31%	1.887	1.26%	0.187	0.38%	2727	12	2741	28	2717	6	-0.9%
S5_452	13.391	1.20%	1.919	1.14%	0.186	0.38%	2708	11	2704	25	2711	6	0.3%
S5_436	13.147	1.17%	1.946	1.12%	0.186	0.36%	2690	11	2673	24	2703	6	1.1%
S5_616	1.851	2.11%	5.605	1.90%	0.075	1.04%	1064	14	1058	19	1074	21	1.5%
S5_618	13.873	1.23%	1.850	1.18%	0.186	0.36%	2741	12	2786	27	2708	6	-2.9%
S5_576	13.092	1.24%	1.928	1.19%	0.183	0.38%	2686	12	2694	26	2681	6	-0.5%
S5_539	14.077	1.35%	1.901	1.29%	0.194	0.41%	2755	13	2724	29	2777	7	1.9%
S5_497	13.625	1.34%	1.863	1.27%	0.184	0.46%	2724	13	2770	29	2690	8	-2.9%
S5_376	15.244	1.82%	1.798	1.77%	0.199	0.48%	2831	17	2850	41	2817	8	-1.2%
S5_208	2.631	1.37%	4.430	1.12%	0.085	0.70%	1309	10	1312	13	1305	14	-0.6%
S5_177	3.380	1.91%	3.838	1.63%	0.094	0.98%	1500	15	1493	22	1510	18	1.2%
S5_203	13.453	1.61%	1.901	1.41%	0.185	0.70%	2712	15	2725	31	2702	12	-0.9%
S5_232	2.167	2.27%	4.945	1.93%	0.078	1.24%	1171	16	1187	21	1140	25	-4.1%
S5_221	5.399	1.73%	2.906	1.52%	0.114	0.78%	1885	15	1906	25	1861	14	-2.5%
S5_194	12.673	1.34%	1.962	1.10%	0.180	0.66%	2656	12	2655	24	2656	11	0.0%
S5_242	1.878	1.48%	5.483	1.15%	0.075	0.91%	1073	10	1080	11	1060	18	-1.9%
S5_319	13.514	2.09%	1.920	1.93%	0.188	0.72%	2716	20	2702	42	2727	12	0.9%
S5_339	13.248	1.59%	1.930	1.39%	0.185	0.70%	2697	15	2692	30	2702	11	0.4%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
S5_713	13.101	1.00%	1.928	0.76%	0.183	0.58%	2687	9	2694	17	2682	10	-0.5%
S5_642	13.816	1.04%	1.845	0.81%	0.185	0.57%	2737	10	2792	18	2697	9	-3.5%
S5_753	15.670	1.15%	1.778	0.94%	0.202	0.59%	2857	11	2876	22	2843	10	-1.2%
S5_712	13.171	1.48%	1.915	1.30%	0.183	0.62%	2692	14	2708	29	2680	10	-1.1%
S5_675	13.959	2.11%	1.865	1.96%	0.189	0.70%	2747	20	2767	44	2732	12	-1.3%
S5_676	1.914	1.28%	5.428	0.97%	0.075	0.83%	1086	9	1090	10	1078	17	-1.1%
S5_591	5.870	1.89%	2.756	1.71%	0.117	0.77%	1957	16	1996	29	1916	14	-4.2%
S5_217	11.724	1.28%	2.173	1.08%	0.185	0.62%	2583	12	2440	22	2696	10	9.5%
S5_985	2.621	1.05%	4.388	0.85%	0.083	0.60%	1306	8	1324	10	1278	12	-3.5%
S5_932	13.757	1.78%	1.850	1.66%	0.185	0.65%	2733	17	2786	37	2694	11	-3.4%
S5_853	11.910	1.19%	2.156	1.04%	0.186	0.55%	2597	11	2457	21	2709	9	9.3%
S5_897	2.238	1.21%	4.921	1.01%	0.080	0.64%	1193	8	1193	11	1194	13	0.1%
S5_884	13.539	1.05%	1.894	0.89%	0.186	0.51%	2718	10	2734	20	2707	8	-1.0%
S5_863	15.303	2.11%	1.769	2.01%	0.196	0.63%	2834	20	2889	47	2796	10	-3.3%
S5_862	11.803	0.92%	2.167	0.74%	0.186	0.49%	2589	9	2446	15	2703	8	9.5%
S5_814	13.627	2.36%	1.904	2.26%	0.188	0.63%	2724	22	2721	50	2726	10	0.2%
S5_757	14.523	2.05%	1.809	1.94%	0.191	0.64%	2785	19	2836	44	2747	10	-3.2%
S5_1069	1.968	1.12%	5.331	0.99%	0.076	0.62%	1105	8	1108	10	1098	12	-1.0%
S5_1161	14.297	1.81%	1.818	1.77%	0.189	0.50%	2770	17	2825	40	2729	8	-3.5%
S5_1122	13.569	1.70%	1.922	1.65%	0.189	0.50%	2720	16	2700	36	2735	8	1.3%
S5_1089	1.995	1.18%	5.329	1.00%	0.077	0.71%	1114	8	1109	10	1124	14	1.3%
S5_1094	13.729	1.26%	1.867	1.20%	0.186	0.44%	2731	12	2765	27	2706	7	-2.2%
S5_1112	5.308	1.57%	2.983	1.47%	0.115	0.62%	1870	13	1864	24	1877	11	0.7%
S5_1106	13.729	1.30%	1.868	1.25%	0.186	0.42%	2731	12	2764	28	2707	7	-2.1%
S5_1039	13.381	1.01%	1.891	0.97%	0.183	0.34%	2707	9	2737	22	2685	6	-1.9%
							>10% Discordant						
S5_29	3.736	1.92%	8.002	1.81%	0.217	0.62%	1579	15	759	13	2957	10	74.3%
S5_240	13.533	1.47%	2.662	1.39%	0.261	0.47%	2718	14	2056	24	3255	7	36.8%
S5_419	3.505	3.21%	5.431	3.06%	0.138	1.05%	1528	25	1089	31	2203	18	50.6%
S5_71	2.781	2.29%	8.079	2.18%	0.163	0.68%	1351	17	752	15	2487	11	69.7%
S5_176	11.371	1.51%	2.368	1.42%	0.195	0.50%	2554	14	2271	27	2787	8	18.5%
S5_109	5.639	3.52%	4.890	3.48%	0.200	0.57%	1922	30	1199	38	2826	9	57.6%
S5_120	2.130	1.72%	5.357	1.44%	0.083	1.02%	1159	12	1103	15	1263	20	12.6%
S5_159	10.391	1.41%	2.828	1.32%	0.213	0.46%	2470	13	1952	22	2930	7	33.4%
S5_75	7.961	1.76%	3.321	1.68%	0.192	0.50%	2227	16	1697	25	2757	8	38.5%
S5_202	1.740	1.78%	6.898	1.50%	0.087	0.95%	1023	11	873	12	1361	18	35.9%
S5_754	11.233	1.10%	2.544	0.86%	0.207	0.60%	2543	10	2137	16	2884	10	25.9%
S5_719	12.424	1.07%	2.741	0.83%	0.247	0.60%	2637	10	2005	14	3165	9	36.7%
S5_1020	3.746	2.18%	5.878	1.84%	0.160	1.28%	1581	17	1013	17	2453	21	58.7%

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
S5_1113	2.310	1.28%	5.590	0.89%	0.094	1.06%	1215	9	1061	9	1501	20	29.3%
S5_1051	5.662	0.89%	5.099	0.84%	0.209	0.33%	1926	8	1154	9	2901	5	60.2%

APPENDIX M

Data Tables for Sample AS2 –

Upper St. Peter Sandstone,

St. Peter Formation

Sample AS2 - Upper St. Peter Sandstone

Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
							< 10% Discordant						
AS2_337	11.120	1.85%	2.160	1.77%	0.174	0.44%	2533	17	2453	36	2598	7	5.6%
AS2_345	12.000	2.37%	2.035	2.28%	0.177	0.55%	2604	22	2576	48	2626	9	1.9%
AS2_109	11.992	2.06%	2.022	1.97%	0.176	0.48%	2604	19	2590	42	2615	8	1.0%
AS2_218	1.883	2.53%	5.583	2.29%	0.076	1.07%	1075	17	1062	22	1101	21	3.5%
AS2_261	13.295	2.16%	1.930	2.07%	0.186	0.52%	2701	20	2691	45	2708	8	0.6%
AS2_185	12.825	2.18%	1.937	2.09%	0.180	0.51%	2667	20	2684	46	2654	8	-1.1%
AS2_36b	2.138	2.03%	5.067	1.88%	0.079	0.74%	1161	14	1161	20	1161	15	0.0%
AS2_36a	1.794	1.89%	5.737	1.76%	0.075	0.65%	1043	12	1036	17	1059	13	2.2%
AS2_58	2.835	1.87%	4.340	1.77%	0.089	0.50%	1365	14	1337	21	1409	10	5.1%
AS2_74	3.154	2.01%	4.028	1.89%	0.092	0.61%	1446	15	1430	24	1470	12	2.8%
AS2_188	2.635	2.01%	4.430	1.73%	0.085	0.86%	1311	15	1312	21	1308	17	-0.3%
AS2_239	13.371	2.49%	1.927	2.28%	0.187	0.79%	2706	23	2695	50	2715	13	0.7%
AS2_194b	12.957	2.02%	1.948	1.79%	0.183	0.74%	2677	19	2671	39	2681	12	0.3%
AS2_191	12.750	2.01%	1.999	1.77%	0.185	0.77%	2661	19	2615	38	2697	13	3.0%
AS2_88	12.069	1.84%	2.042	1.59%	0.179	0.73%	2610	17	2569	34	2641	12	2.7%
AS2_201	14.077	2.21%	1.808	1.99%	0.185	0.77%	2755	21	2838	45	2695	13	-5.3%
AS2_314	1.616	2.02%	6.200	1.71%	0.073	0.92%	976	13	964	15	1004	19	4.0%
AS2_283	2.344	1.87%	4.820	1.60%	0.082	0.81%	1226	13	1215	18	1244	16	2.3%
AS2_301	1.973	1.88%	5.432	1.61%	0.078	0.81%	1106	13	1089	16	1140	16	4.4%
AS2_367	2.140	2.07%	5.125	1.77%	0.080	0.94%	1162	14	1149	19	1185	18	3.1%
AS2_502	13.411	1.25%	1.922	1.19%	0.187	0.40%	2709	12	2700	26	2715	7	0.6%
AS2_406	12.888	1.35%	1.956	1.29%	0.183	0.37%	2671	13	2662	28	2679	6	0.6%
AS2_509a	13.076	1.22%	1.961	1.17%	0.186	0.35%	2685	11	2656	25	2707	6	1.9%
AS2_395	2.278	1.43%	4.855	1.31%	0.080	0.59%	1205	10	1207	14	1202	12	-0.4%
AS2_432	10.453	1.30%	2.201	1.25%	0.167	0.38%	2476	12	2415	25	2526	6	4.4%
AS2_383	2.287	1.34%	4.966	1.23%	0.082	0.56%	1208	9	1183	13	1254	11	5.7%
AS2_192	2.635	1.37%	4.498	1.26%	0.086	0.57%	1310	10	1294	15	1337	11	3.2%
AS2_252	13.123	1.83%	1.960	1.77%	0.187	0.46%	2689	17	2658	38	2712	8	2.0%
AS2_214	1.686	1.58%	5.976	1.41%	0.073	0.76%	1003	10	997	13	1016	15	1.8%
AS2_127	1.884	1.31%	5.541	1.18%	0.076	0.59%	1076	9	1070	12	1088	12	1.7%
AS2_1145	3.265	2.36%	3.881	2.24%	0.092	0.77%	1473	18	1478	30	1466	14	-0.8%
AS2_1188a	1.869	2.74%	5.726	2.55%	0.078	1.10%	1070	18	1038	24	1137	22	8.7%
AS2_1227	13.811	2.68%	1.876	2.62%	0.188	0.58%	2737	25	2755	58	2724	9	-1.1%
AS2_910	12.645	2.37%	1.933	2.32%	0.177	0.49%	2654	22	2688	51	2628	8	-2.3%
AS2_739a	4.671	2.41%	3.165	2.33%	0.107	0.65%	1762	20	1770	36	1753	12	-1.0%
AS2_702	1.790	2.40%	5.571	2.24%	0.072	0.91%	1042	15	1064	22	995	18	-7.0%

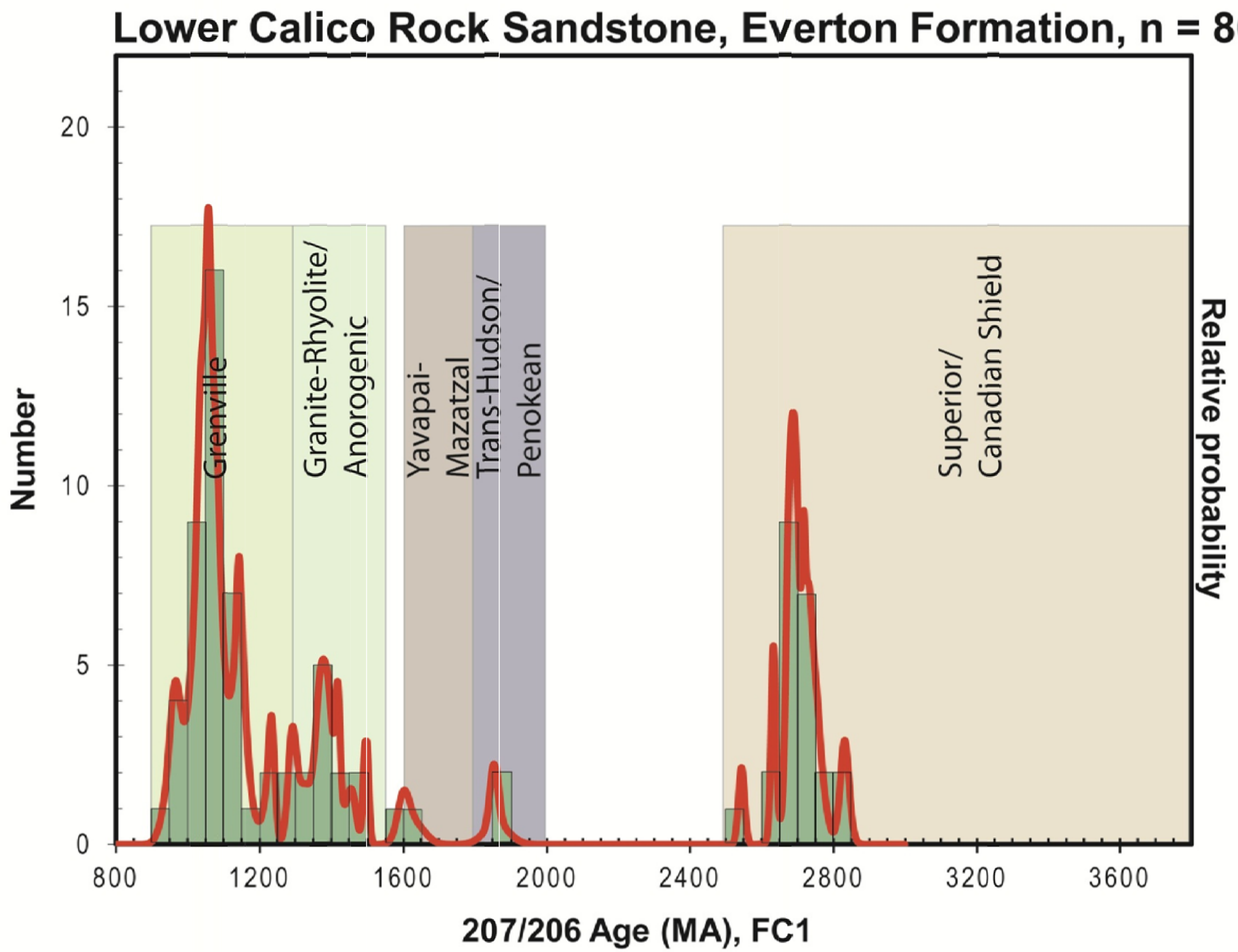
Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
AS2_566	1.764	1.89%	5.781	1.83%	0.074	0.50%	1032	12	1029	17	1040	10	1.1%
AS2_402	1.911	2.19%	5.524	2.06%	0.077	0.79%	1085	14	1073	20	1110	16	3.4%
AS2_444	13.363	1.98%	1.894	1.94%	0.184	0.37%	2706	19	2732	43	2686	6	-1.7%
AS2_428	14.233	2.07%	1.817	2.03%	0.188	0.40%	2765	19	2826	46	2721	7	-3.8%
AS2_837	2.389	1.75%	4.621	1.46%	0.080	0.94%	1239	12	1263	17	1199	18	-5.3%
AS2_780	13.284	1.19%	1.893	0.95%	0.182	0.60%	2700	11	2735	21	2674	10	-2.3%
AS2_1091	11.091	1.24%	2.215	1.01%	0.178	0.60%	2531	11	2402	20	2636	10	8.9%
AS2_921	13.206	3.26%	1.933	3.11%	0.185	0.87%	2694	30	2688	68	2699	14	0.4%
AS2_828	12.991	1.58%	1.929	1.38%	0.182	0.68%	2679	15	2692	30	2669	11	-0.8%
AS2_1010	2.126	1.44%	4.970	1.14%	0.077	0.85%	1157	10	1182	12	1112	17	-6.3%
AS2_1020	13.090	1.20%	1.930	0.96%	0.183	0.62%	2686	11	2691	21	2682	10	-0.3%
AS2_1214	13.971	2.42%	1.838	2.15%	0.186	0.94%	2748	23	2801	49	2709	15	-3.4%
AS2_1113	1.991	1.68%	5.359	1.18%	0.077	1.12%	1112	11	1103	12	1131	22	2.5%
AS2_1263	13.847	1.56%	1.864	1.17%	0.187	0.86%	2739	15	2769	26	2718	14	-1.9%
AS2_1069	2.338	1.58%	4.786	1.15%	0.081	0.94%	1224	11	1223	13	1225	18	0.2%
AS2_1123	14.813	2.11%	1.777	1.80%	0.191	0.97%	2803	20	2878	42	2750	16	-4.7%
AS2_952	1.905	1.90%	5.535	1.42%	0.076	1.18%	1083	13	1071	14	1108	23	3.4%
AS2_839	12.754	1.53%	1.960	1.13%	0.181	0.87%	2662	14	2658	25	2665	14	0.3%
AS2_1193	13.425	1.38%	1.906	0.93%	0.186	0.85%	2710	13	2719	21	2703	14	-0.6%
AS2_1315	1.891	3.65%	5.677	3.20%	0.078	1.80%	1078	24	1046	31	1144	35	8.6%
AS2_1301	13.600	2.24%	1.894	2.12%	0.187	0.63%	2722	21	2733	47	2714	10	-0.7%
AS2_1403b	2.007	1.92%	5.293	1.76%	0.077	0.73%	1118	13	1116	18	1123	15	0.6%
AS2_1403a	1.873	1.82%	5.545	1.68%	0.075	0.65%	1072	12	1069	16	1078	13	0.8%
AS2_1365	1.893	2.09%	5.550	1.89%	0.076	0.89%	1078	14	1068	19	1100	18	2.9%
AS2_1322	2.196	2.93%	4.982	2.65%	0.079	1.31%	1180	20	1179	29	1181	26	0.1%
AS2_1206	3.136	2.08%	4.030	1.89%	0.092	0.86%	1442	16	1429	24	1460	16	2.2%
AS2_1308	1.920	2.02%	5.480	1.81%	0.076	0.90%	1088	13	1081	18	1103	18	2.0%
AS2_1373	1.806	2.22%	5.844	1.94%	0.077	1.11%	1048	14	1018	18	1109	22	8.2%
AS2_1190	14.605	3.01%	1.787	2.89%	0.189	0.79%	2790	28	2865	67	2736	13	-4.7%
AS2_1133	1.883	1.60%	5.569	1.09%	0.076	1.02%	1075	11	1065	11	1096	20	2.9%
AS2_1194	13.250	1.69%	1.921	1.28%	0.185	0.90%	2698	16	2702	28	2694	15	-0.3%
AS2_1186	1.751	1.56%	5.860	1.01%	0.074	1.04%	1027	10	1016	10	1052	21	3.5%
AS2_1187	2.561	1.58%	4.564	1.06%	0.085	1.01%	1289	11	1277	12	1310	19	2.5%
AS2_1067	13.672	1.74%	1.925	1.34%	0.191	0.91%	2727	16	2696	30	2750	15	2.0%
AS2_920	2.646	1.53%	4.467	1.02%	0.086	0.97%	1313	11	1302	12	1332	19	2.2%
AS2_857	12.813	1.41%	1.946	0.92%	0.181	0.87%	2666	13	2673	20	2661	14	-0.5%
AS2_707	11.448	1.43%	2.125	0.92%	0.176	0.90%	2560	13	2487	19	2619	15	5.1%
AS2_799	13.372	1.65%	1.953	1.24%	0.189	0.90%	2706	15	2665	27	2737	15	2.6%
AS2_1163	3.921	1.46%	3.562	0.95%	0.101	0.93%	1618	12	1595	13	1648	17	3.2%

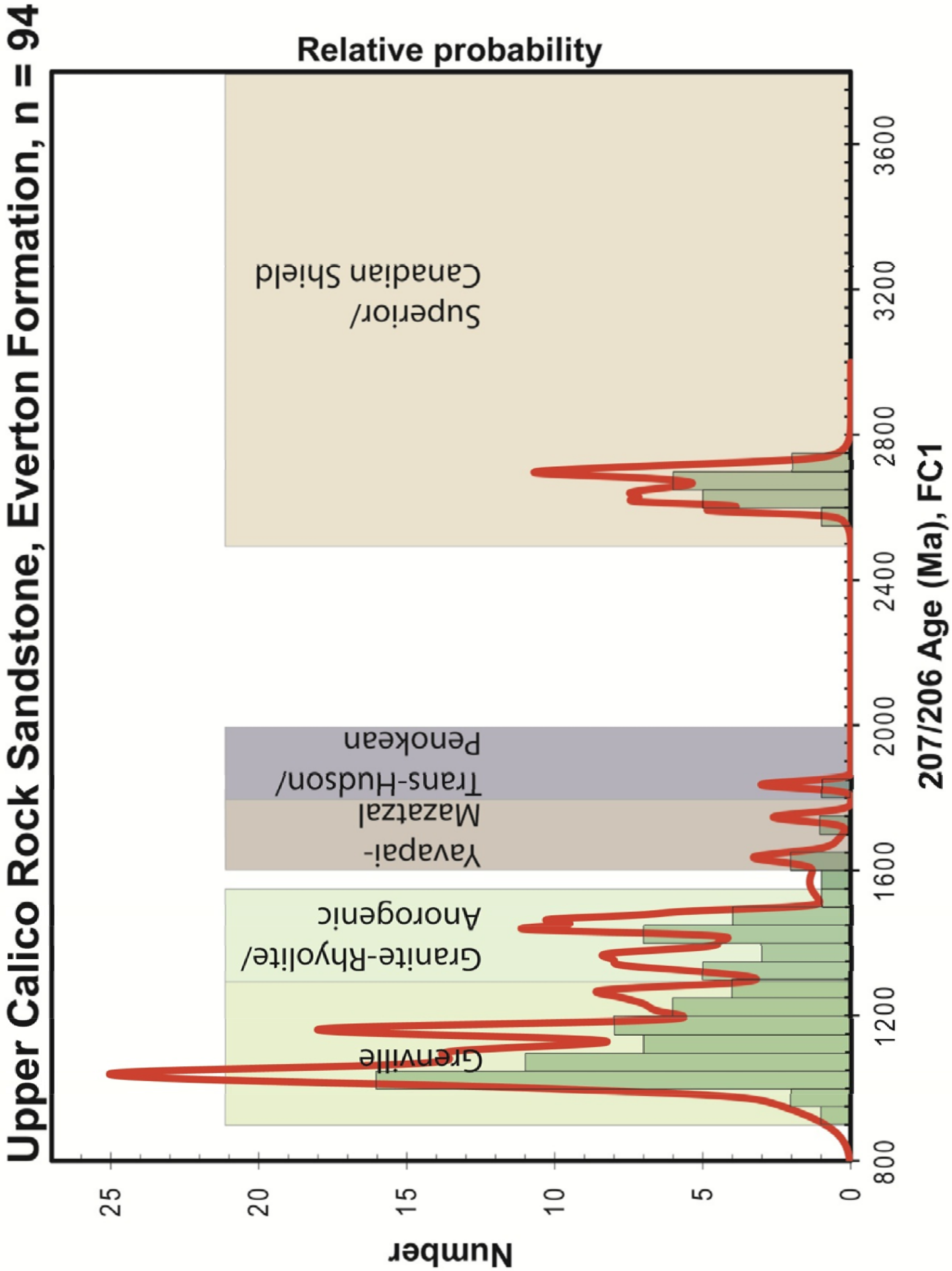
Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
AS2_2812	13.209	1.31%	1.922	1.25%	0.184	0.37%	2695	12	2701	28	2690	6	-0.4%
AS2_2519	2.634	2.08%	4.476	1.94%	0.086	0.82%	1310	15	1300	23	1327	16	2.1%
AS2_2466	2.037	1.36%	5.213	1.26%	0.077	0.55%	1128	9	1131	13	1121	11	-0.9%
AS2_2677	12.477	1.30%	2.031	1.24%	0.184	0.41%	2641	12	2580	26	2688	7	4.0%
AS2_2776	3.158	1.56%	3.998	1.45%	0.092	0.59%	1447	12	1439	19	1459	11	1.3%
AS2_2695	2.546	3.09%	4.558	2.89%	0.084	1.21%	1285	22	1279	33	1296	23	1.3%
AS2_2741	2.158	1.72%	5.191	1.54%	0.081	0.84%	1168	12	1136	16	1227	16	7.5%
AS2_2755	1.946	1.33%	5.395	1.26%	0.076	0.45%	1097	9	1096	13	1099	9	0.3%
AS2_2841	10.254	1.53%	2.192	1.47%	0.163	0.43%	2458	14	2423	30	2487	7	2.6%
AS2_2797	1.667	1.54%	6.052	1.39%	0.073	0.71%	996	10	986	13	1019	14	3.2%
AS2_2060	2.037	1.59%	5.245	1.45%	0.077	0.69%	1128	11	1125	15	1134	14	0.8%
AS2_1948	15.382	2.32%	1.771	2.25%	0.198	0.60%	2839	22	2886	52	2806	10	-2.8%
AS2_2146	2.108	1.55%	5.177	1.42%	0.079	0.66%	1152	11	1138	15	1176	13	3.2%
AS2_2095	4.744	1.56%	3.316	1.47%	0.114	0.54%	1775	13	1699	22	1866	10	8.9%
AS2_2150	13.380	2.14%	1.895	2.05%	0.184	0.62%	2707	20	2732	46	2688	10	-1.7%
AS2_2219b	1.804	1.57%	5.570	1.46%	0.073	0.58%	1047	10	1064	14	1011	12	-5.3%
AS2_2219a	6.134	1.67%	2.724	1.57%	0.121	0.58%	1995	14	2016	27	1973	10	-2.2%
AS2_2344	3.184	1.85%	4.009	1.76%	0.093	0.59%	1453	14	1435	23	1479	11	3.0%
AS2_2378	17.742	3.34%	1.682	3.26%	0.216	0.74%	2976	32	3008	78	2954	12	-1.8%
AS2_2550	2.816	2.14%	4.297	2.00%	0.088	0.82%	1360	16	1349	24	1377	16	2.0%
AS2_1896	12.813	1.45%	2.017	1.39%	0.187	0.46%	2666	14	2596	30	2720	8	4.6%
AS2_1799	3.015	1.14%	4.221	1.06%	0.092	0.48%	1411	9	1371	13	1473	9	7.0%
AS2_1662	2.747	1.37%	4.392	1.27%	0.088	0.59%	1341	10	1322	15	1372	11	3.6%
AS2_1625	12.671	1.63%	1.996	1.59%	0.183	0.40%	2655	15	2618	34	2684	7	2.5%
AS2_1753	2.083	1.30%	5.224	1.15%	0.079	0.68%	1143	9	1129	12	1171	13	3.5%
AS2_1993	17.297	1.37%	1.764	1.33%	0.221	0.37%	2951	13	2895	31	2990	6	3.2%
AS2_1909	2.759	1.25%	4.332	1.13%	0.087	0.58%	1345	9	1339	14	1354	11	1.1%
AS2_1873	13.482	2.09%	1.973	2.04%	0.193	0.53%	2714	20	2643	44	2767	9	4.5%
							>10% Discordant						
AS2_165	2.957	1.95%	5.167	1.85%	0.111	0.54%	1397	15	1140	19	1813	10	37.1%
AS2_286	2.057	1.89%	5.465	1.62%	0.082	0.80%	1135	13	1083	16	1235	16	12.3%
AS2_173	4.134	1.50%	6.447	1.44%	0.193	0.40%	1661	12	930	12	2770	7	66.4%
AS2_1125	2.402	3.89%	4.921	3.68%	0.086	1.37%	1243	28	1193	40	1332	26	10.5%
AS2_1009a	2.873	1.49%	4.412	1.28%	0.092	0.68%	1375	11	1317	15	1466	13	10.2%
AS2_975	12.131	1.57%	2.230	1.38%	0.196	0.64%	2615	15	2388	27	2795	10	14.6%
AS2_1034	2.740	1.46%	4.547	1.17%	0.090	0.82%	1339	11	1281	14	1433	16	10.6%
AS2_1023	2.179	1.80%	5.392	1.50%	0.085	0.97%	1174	12	1097	15	1321	19	17.0%
AS2_1274	2.142	3.14%	7.392	2.94%	0.115	0.92%	1162	22	818	23	1877	16	56.4%
AS2_1199	2.170	1.84%	6.237	1.69%	0.098	0.69%	1172	13	959	15	1590	13	39.7%

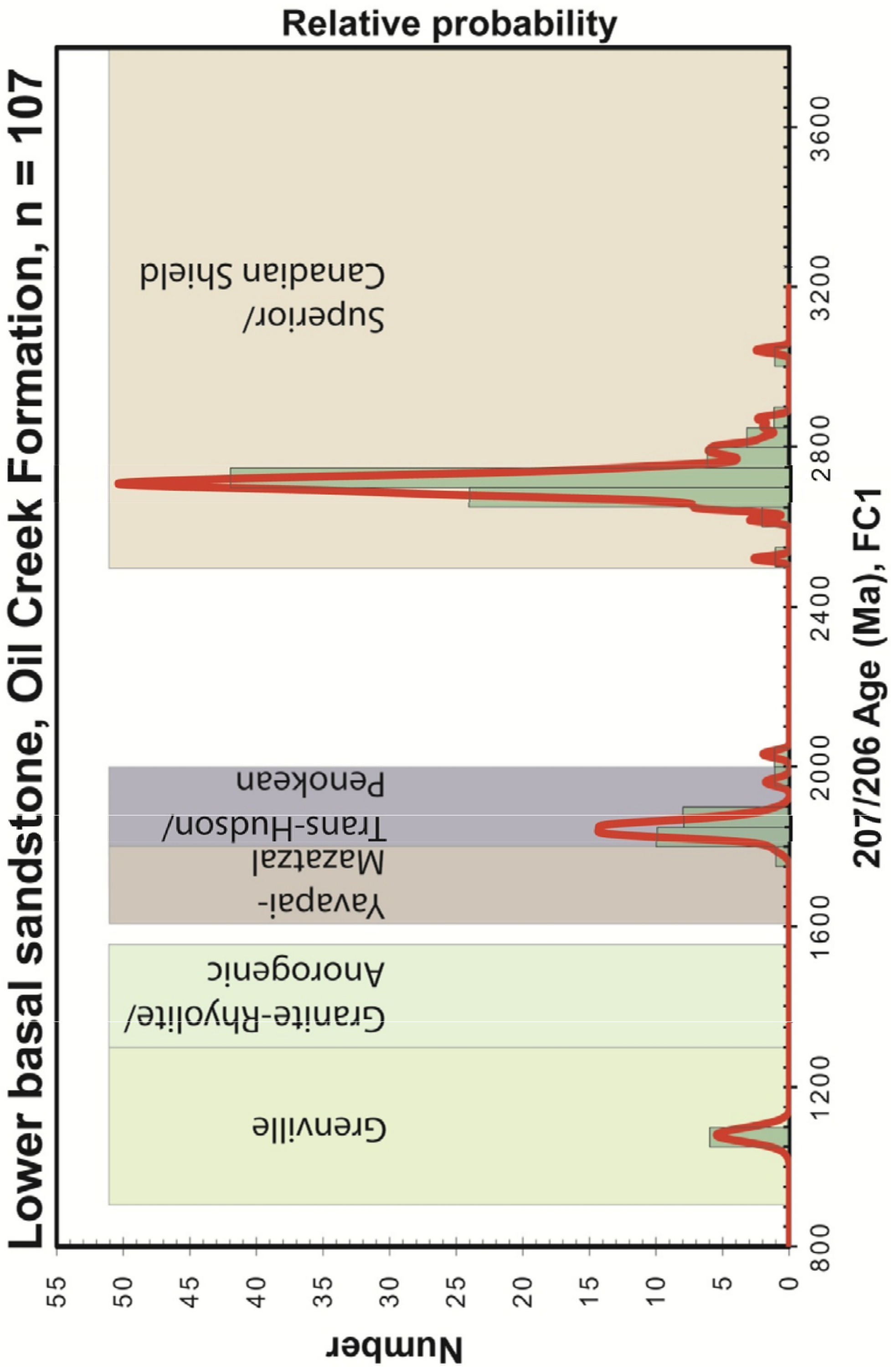
Sample Name	$^{207}U/^{235}Pb$	1-σ (%)	$^{238}U/^{206}Pb$	1-σ (%)	$^{207}Pb/^{206}Pb$	1-σ %	$^{207}Pb/^{235}U$ age (Ma)	1-σ (Ma)	$^{206}Pb/^{238}U$ age (Ma)	1-σ (Ma)	$^{207}Pb/^{206}Pb$ age (Ma)	1-σ (Ma)	Discordance (%)
AS2_1814a	1.736	1.24%	6.294	1.10%	0.079	0.62%	1022	8	951	10	1179	12	19.4%
AS2_1676	1.973	2.43%	5.591	2.00%	0.080	1.54%	1106	16	1061	20	1197	30	11.4%

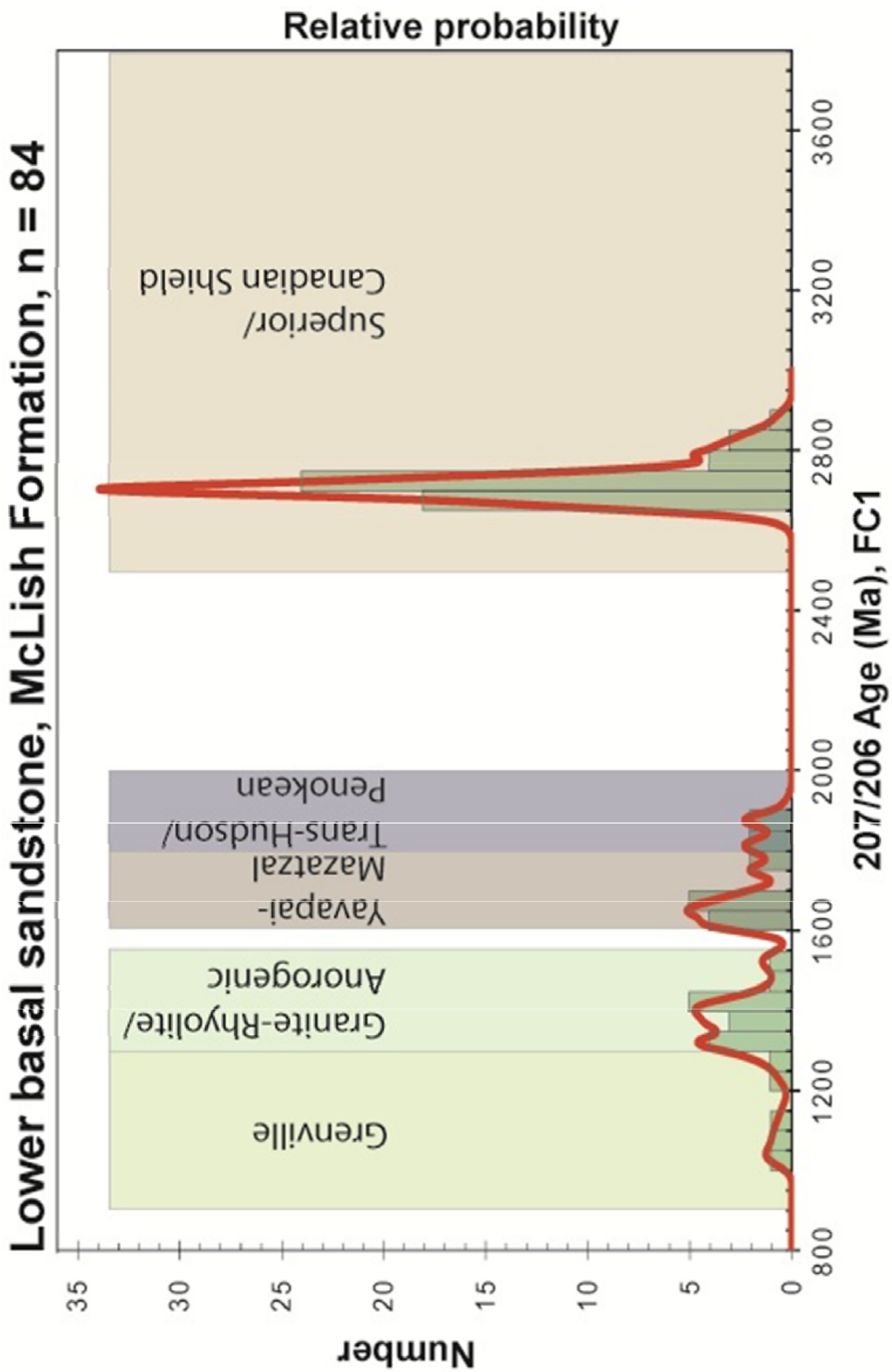
APPENDIX N

Supplemental Probability-Density Plots

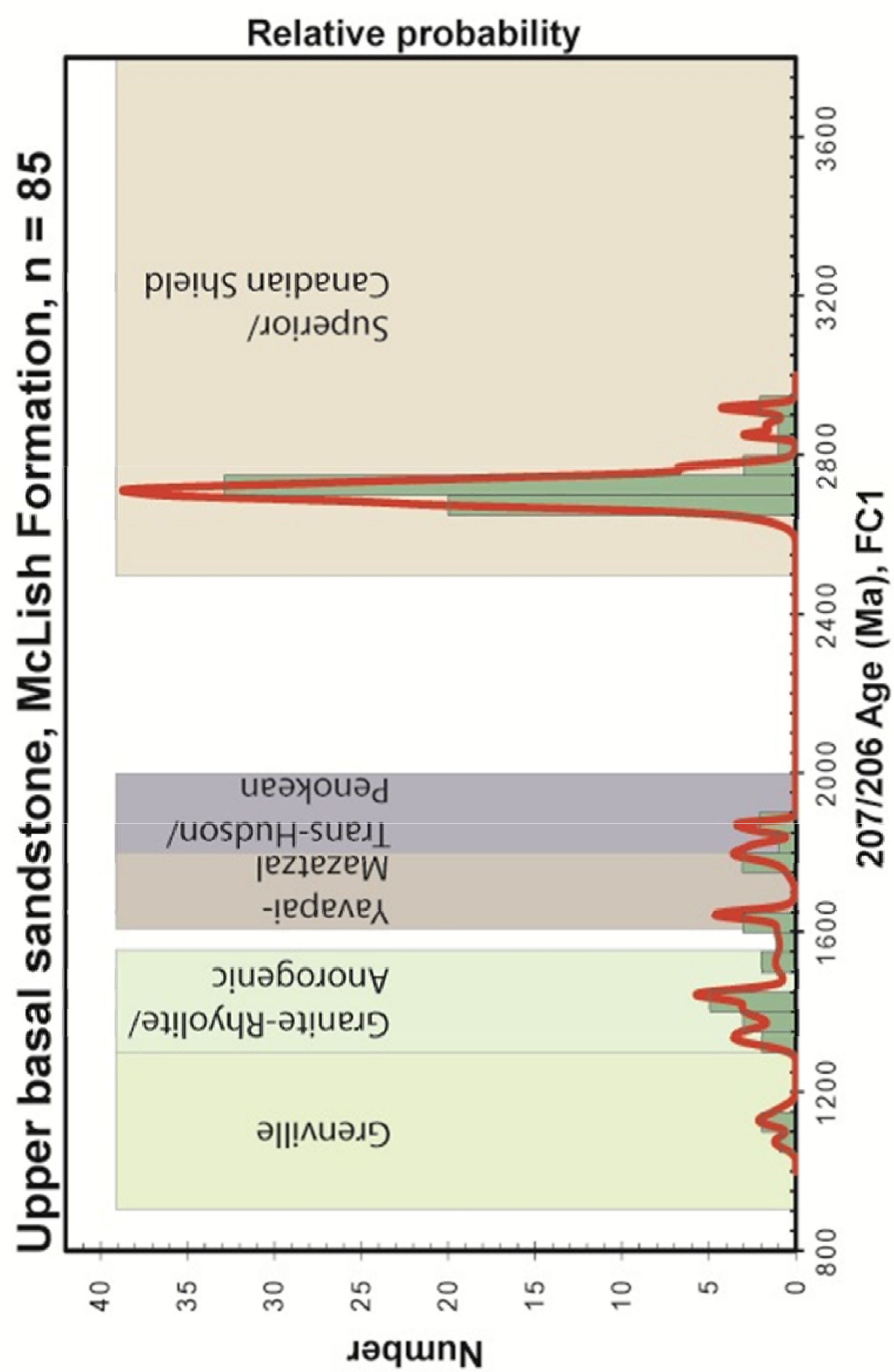

Lower Calico Rock Sandstone, Everton Formation, n = 80
Number
Relative probability
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield
0
5
10
15
20
800
1200
1600
2000
2400
2800
3200
3600
207/206 Age (MA), FC1

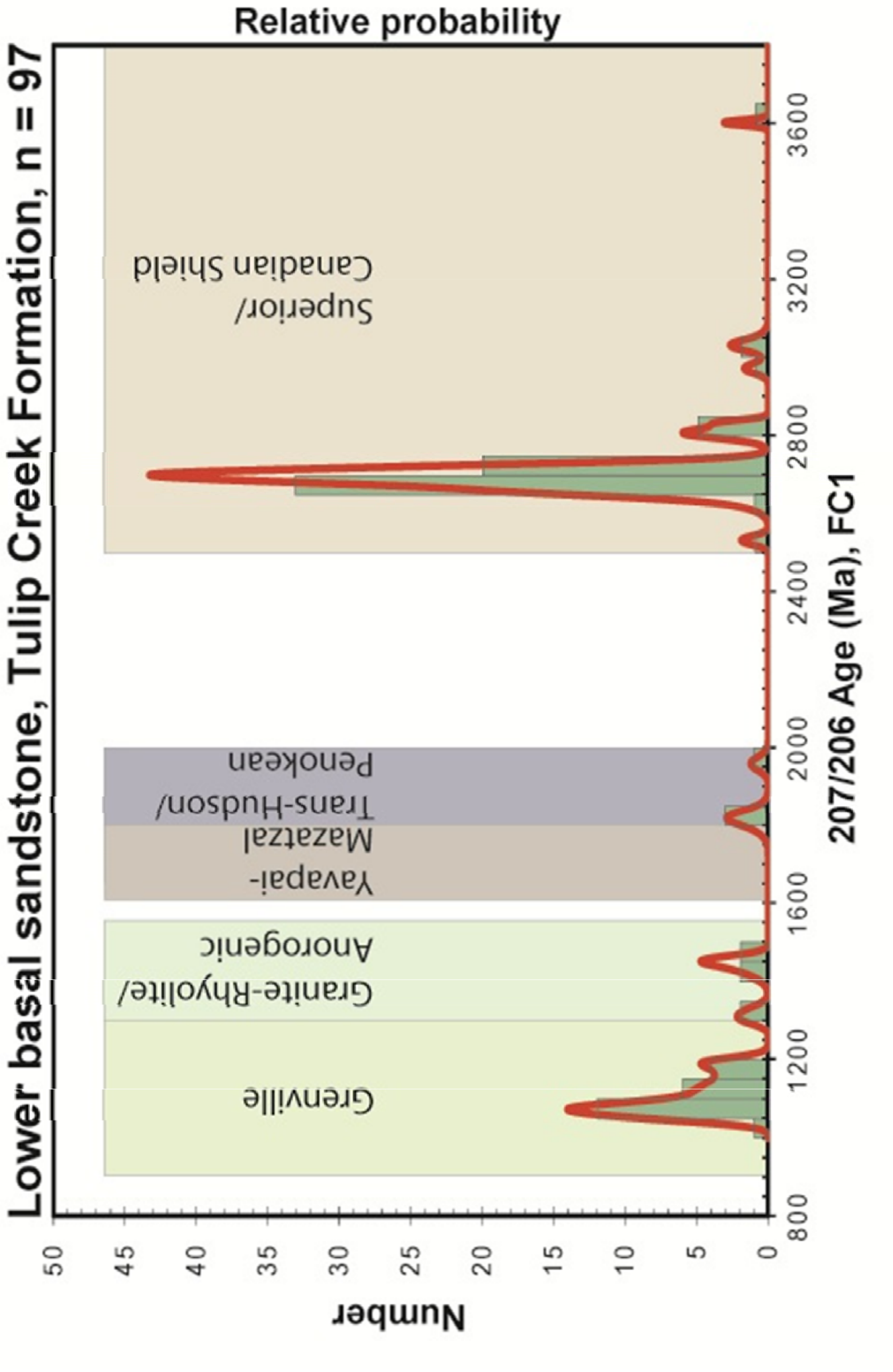

Upper Calico Rock Sandstone, Everton Formation, n = 94
Relative probability
Number
207/206 Age (Ma), FC1
0
5
10
15
20
25
800
1200
1600
2000
2400
2800
3200
3600
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield


Lower basal sandstone, Oil Creek Formation, n = 107
Relative probability
Number
207/206 Age (Ma), FC1
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield

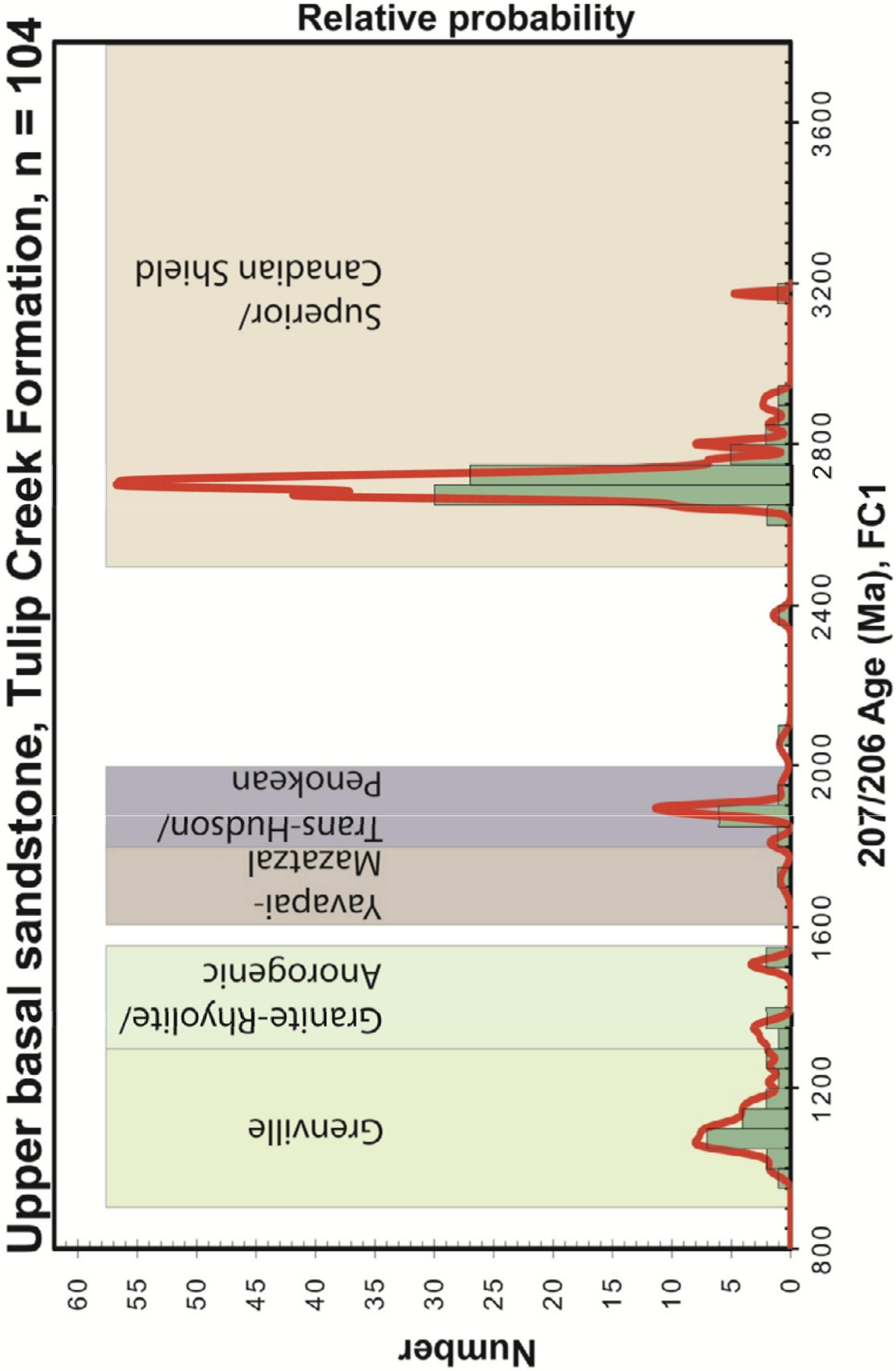


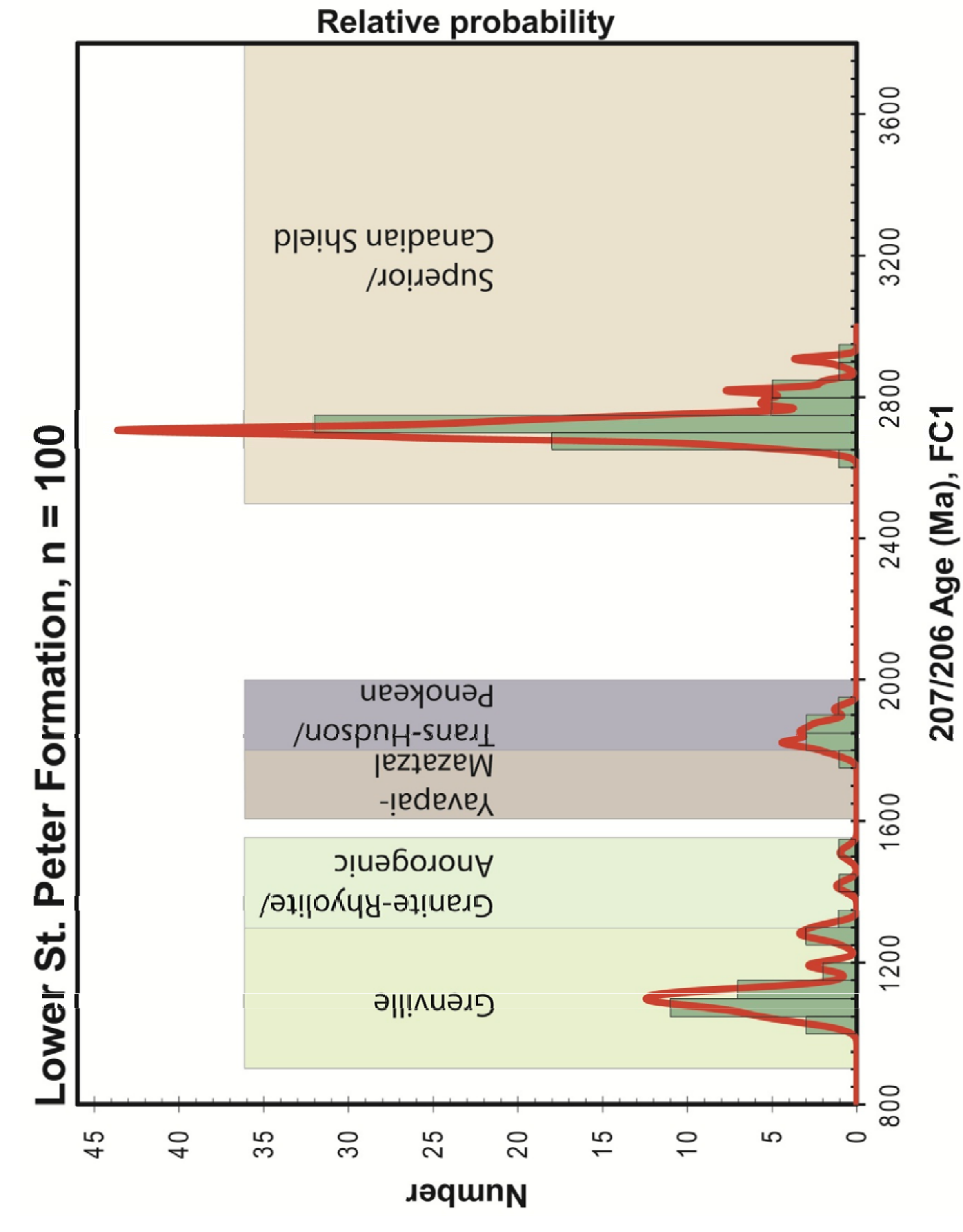
Lower basal sandstone, McLish Formation, n = 84
Relative probability
Number
207/206 Age (Ma), FC1
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield


Upper basal sandstone, McLish Formation, n = 85
Relative probability
Number
207/206 Age (Ma), FC1
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield
0
5
10
15
20
25
30
35
40
800
1200
1600
2000
2400
2800
3200
3600

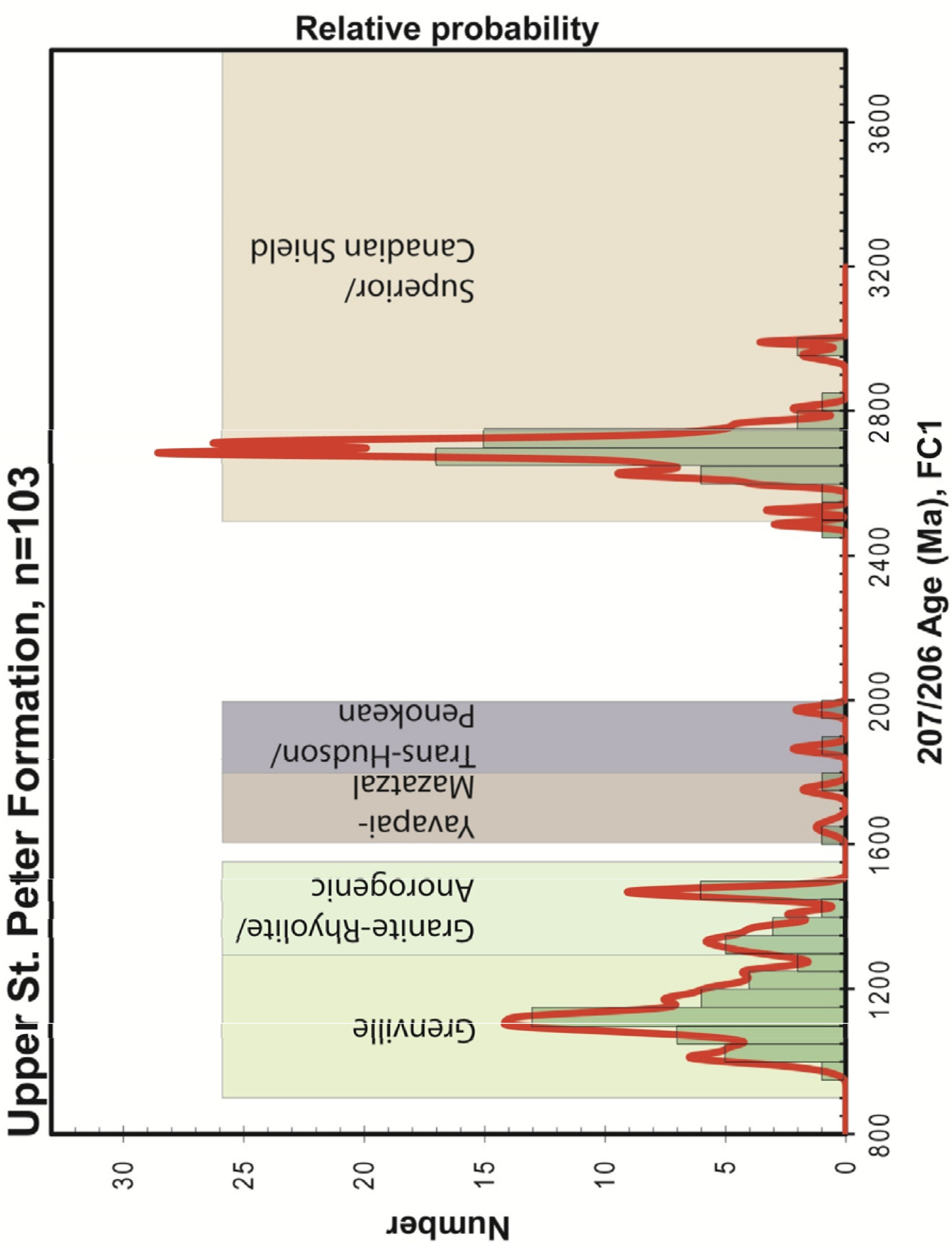


Lower basal sandstone, Tulip Creek Formation, n = 97
Relative probability
Number
207/206 Age (Ma), FC1
0
5
10
15
20
25
30
35
40
45
50
800
1200
1600
2000
2400
2800
3200
3600
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield


Upper basal sandstone, Tulip Creek Formation, n = 104
Relative probability
Number
207/206 Age (Ma), FC1
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield
0
5
10
15
20
25
30
35
40
45
50
55
60
800
1200
1600
2000
2400
2800
3200
3600



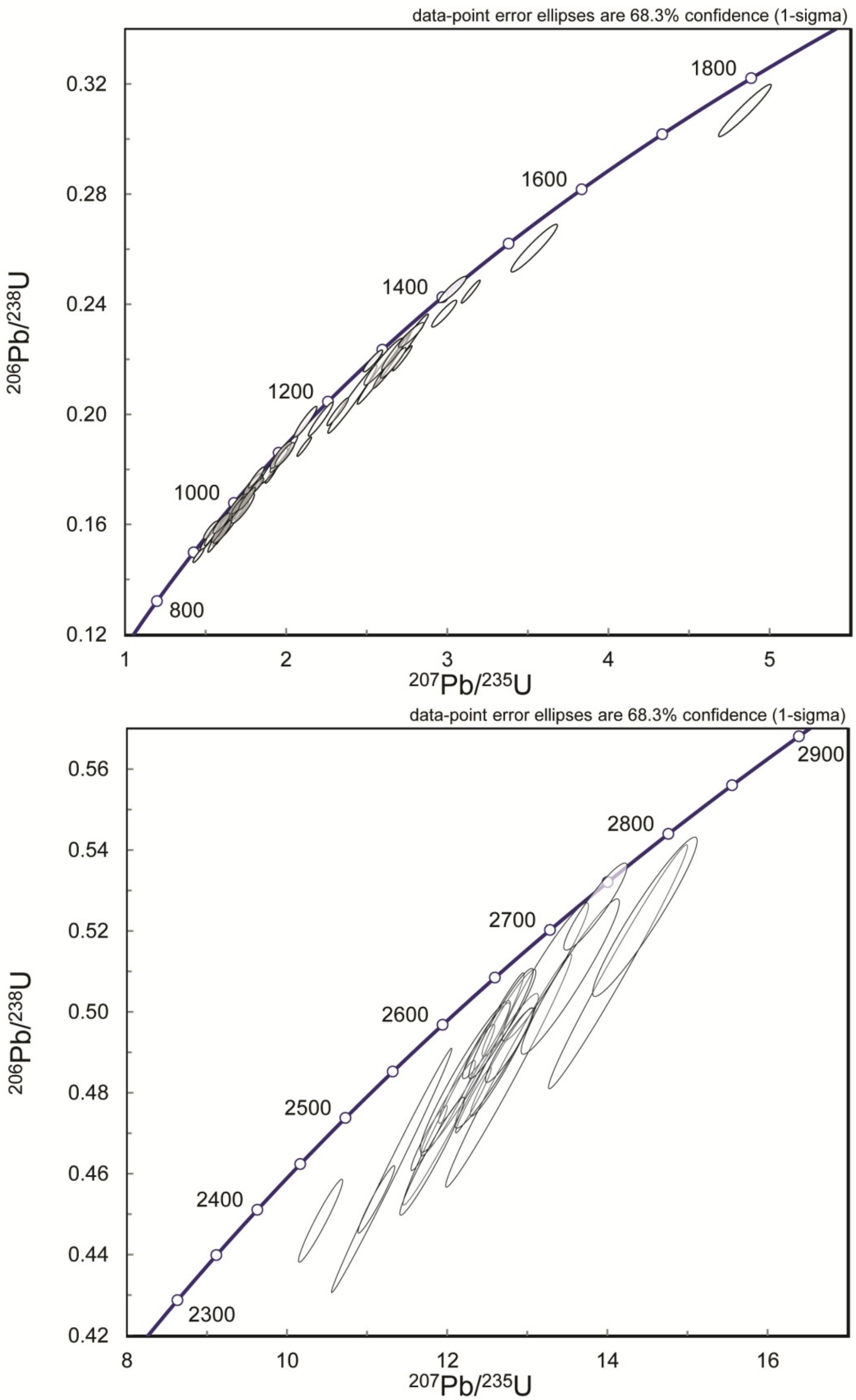
Lower St. Peter Formation, n = 100
Relative probability
Number
207/206 Age (Ma), FC1
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield


Upper St. Peter Formation, n=103
Relative probability
Number
207/206 Age (Ma), FC1
Grenville
Granite-Rhyolite/
Anorogenic
Yavapai-
Mazatzal
Trans-Hudson/
Penokean
Superior/
Canadian Shield

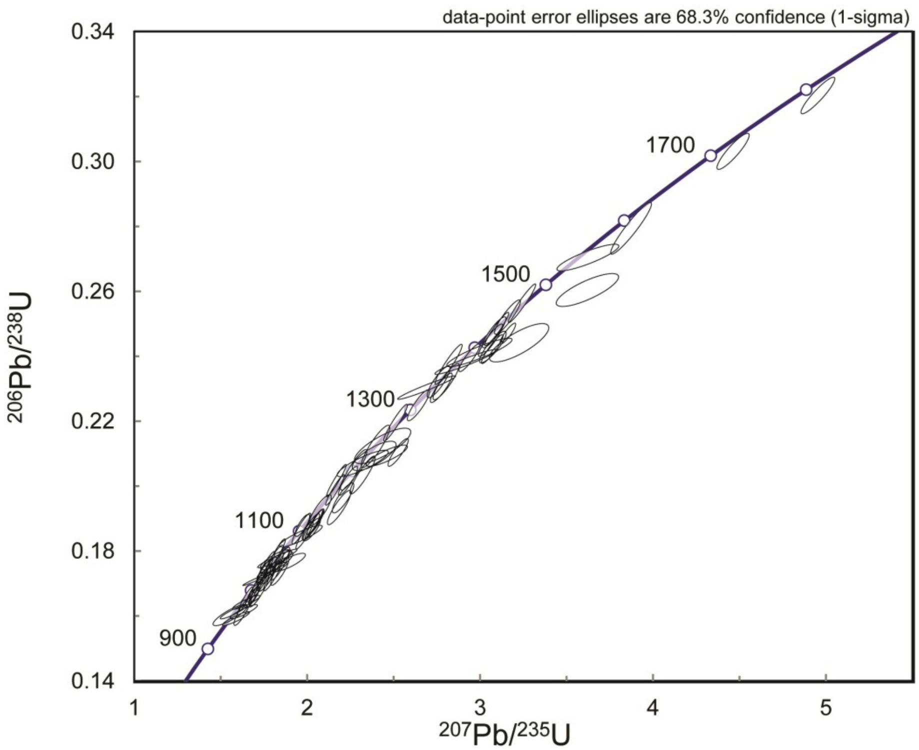
APPENDIX O

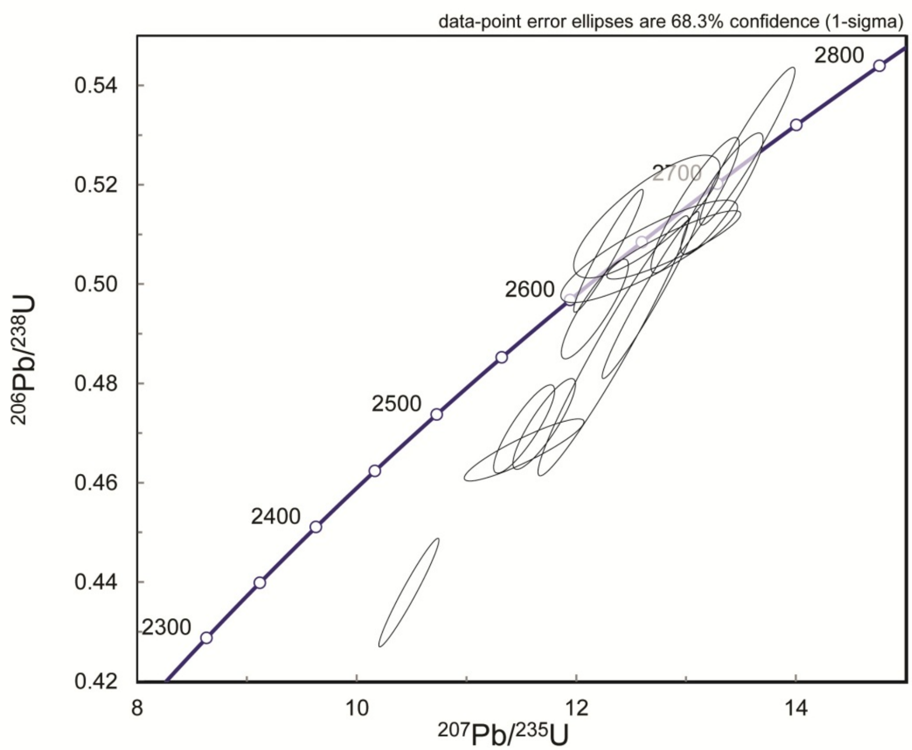
Wetherill Concordia Plots

Sample BC – Lower Calico Rock Sandstone

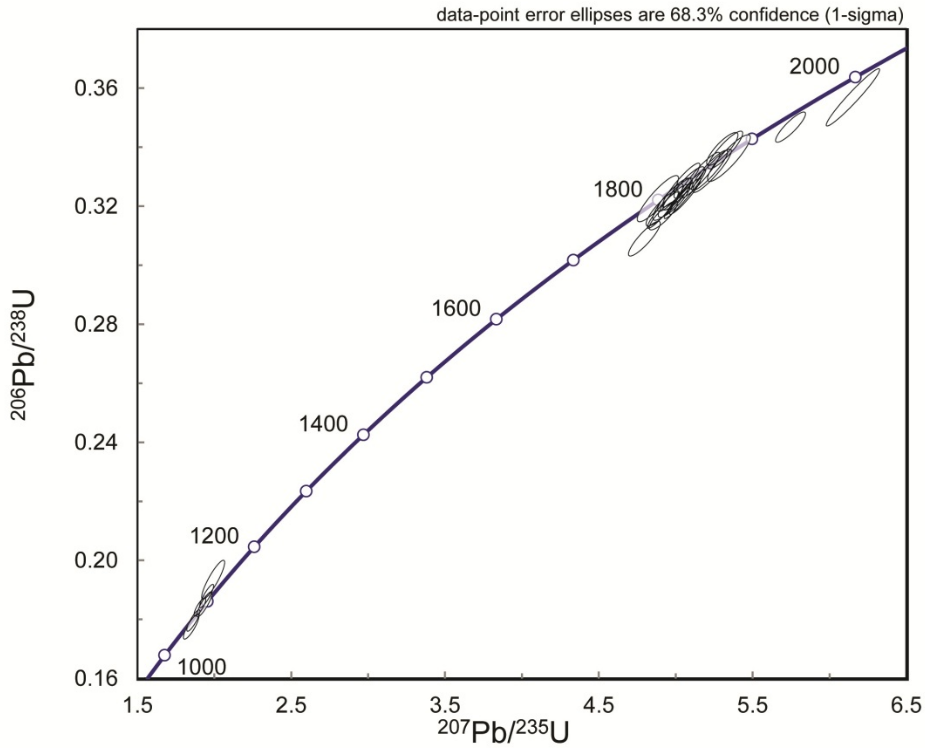


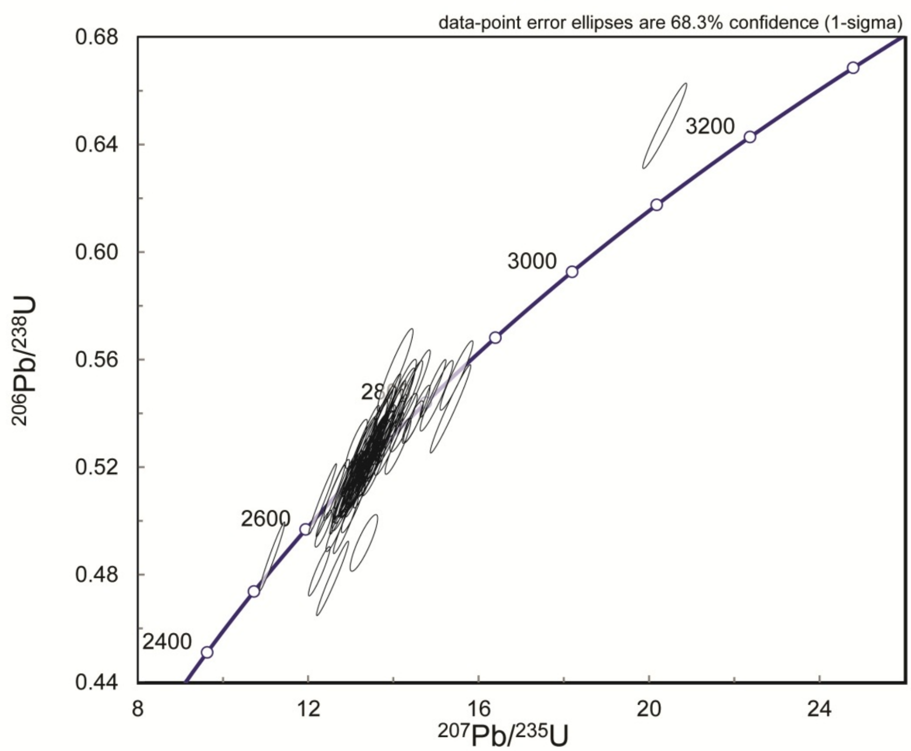
Sample CR – Uppeer Calico Rock Sandstone



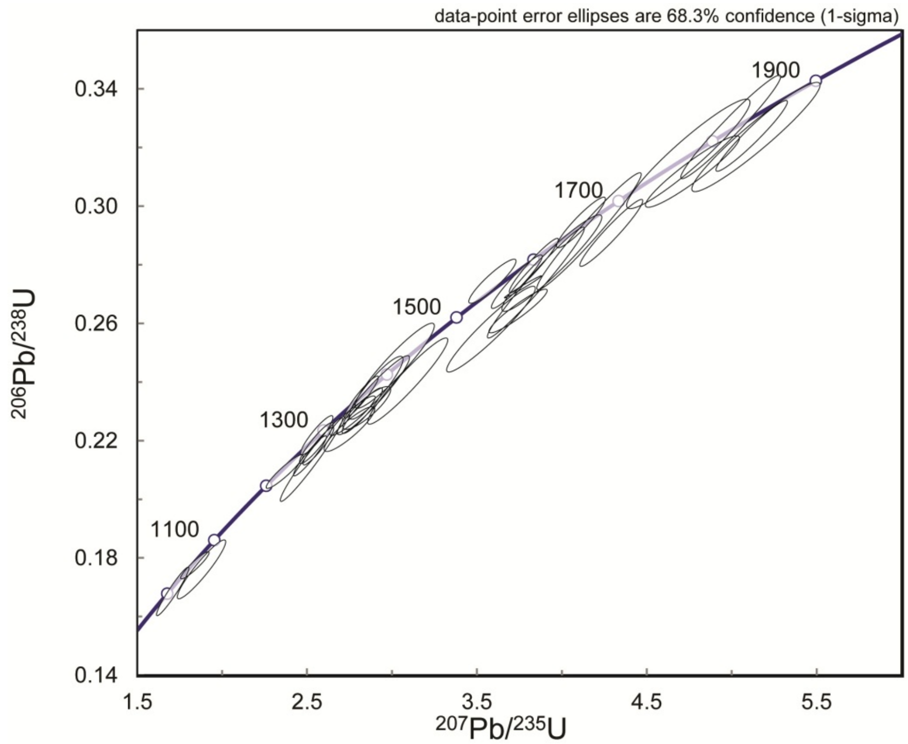


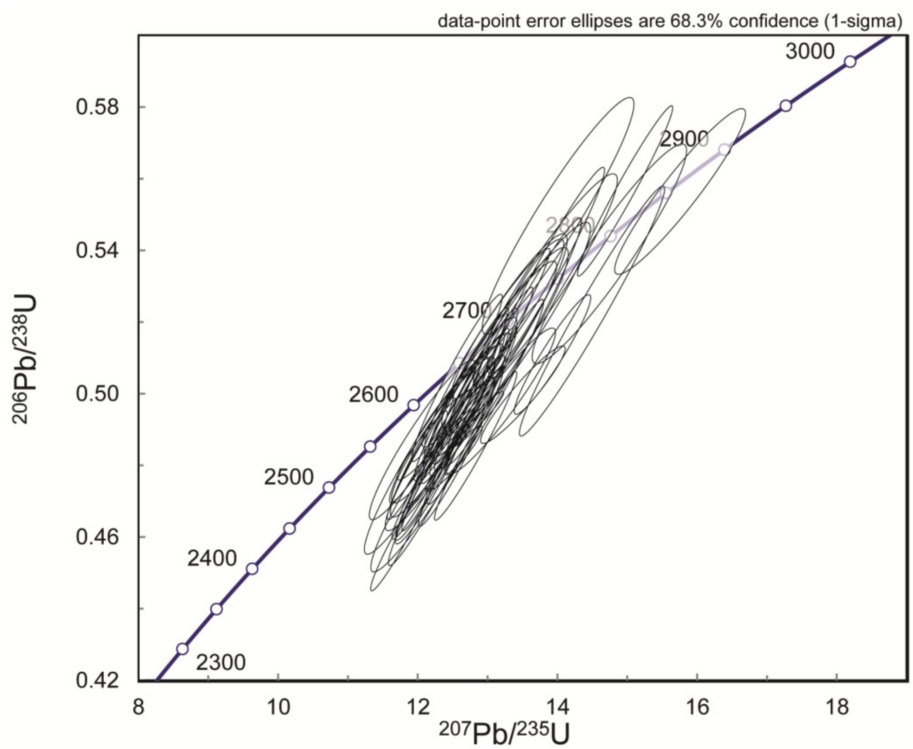
Sample USSB – Lower Basal Oil Creek Sandstone



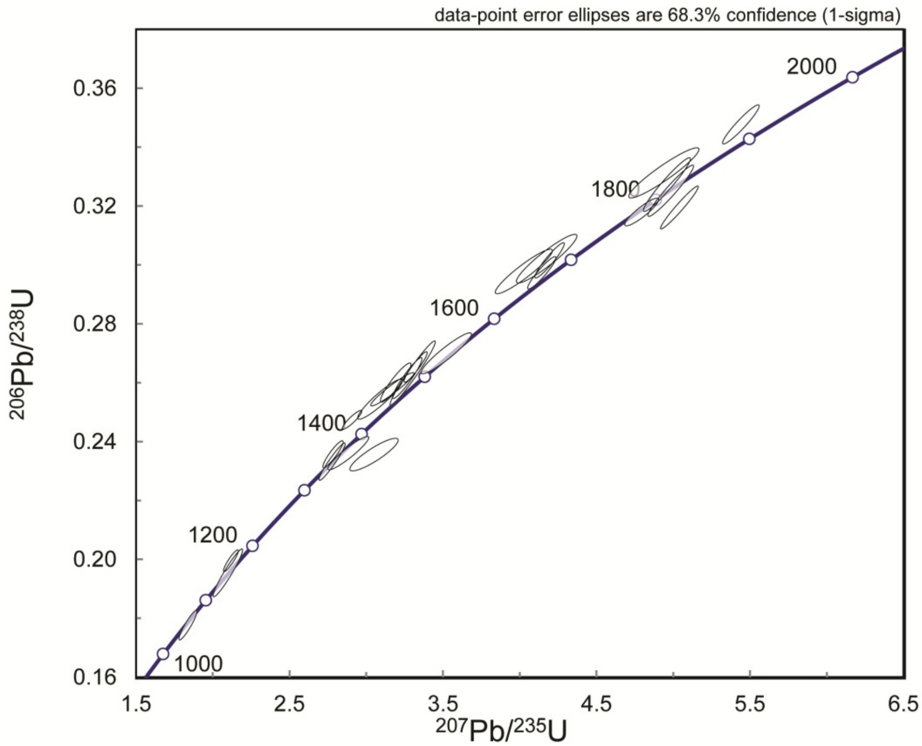


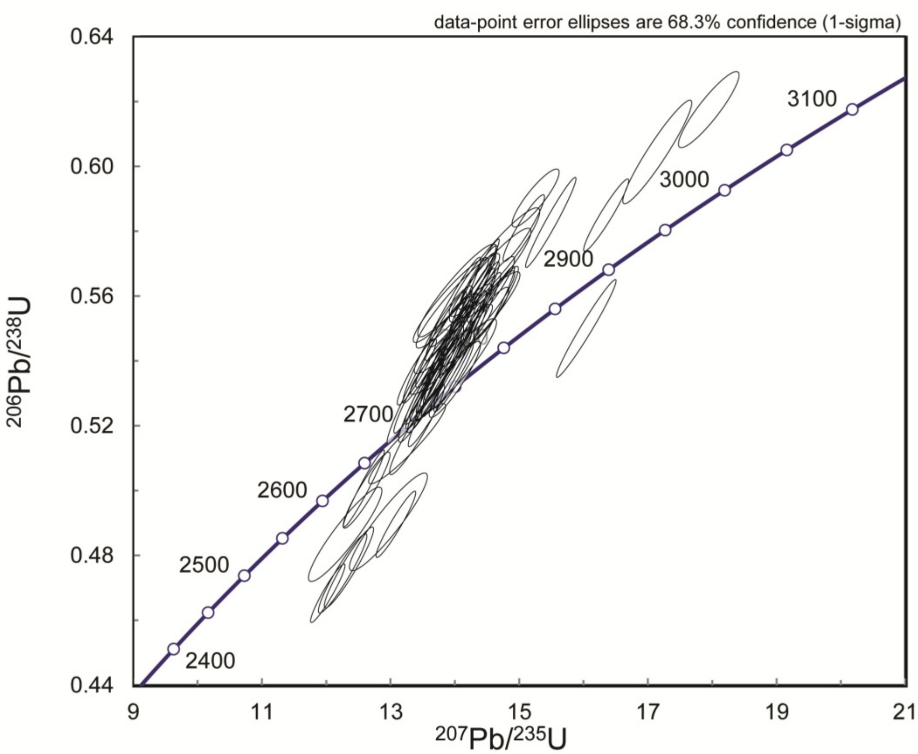
Sample BM – Lower Basal McLish Sandstone



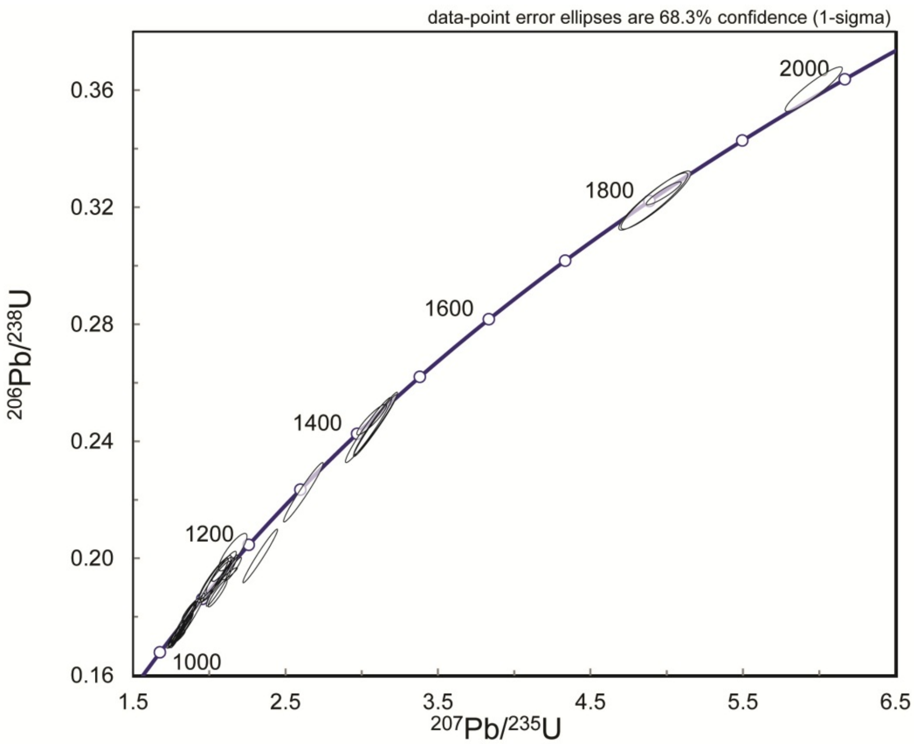


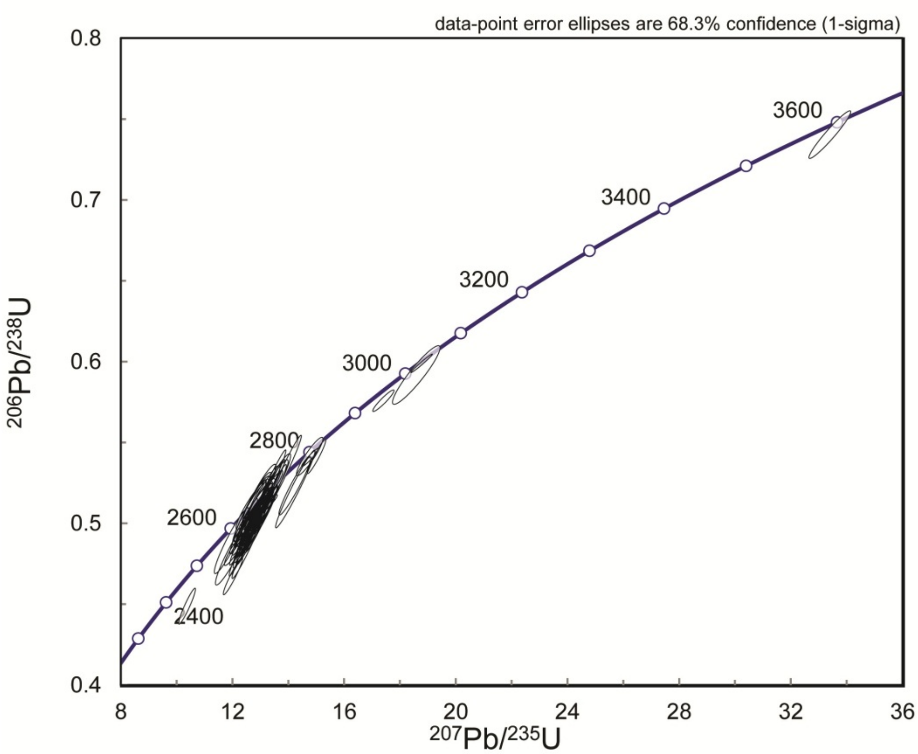
Sample TM – Upper Basal McLish Sandstone



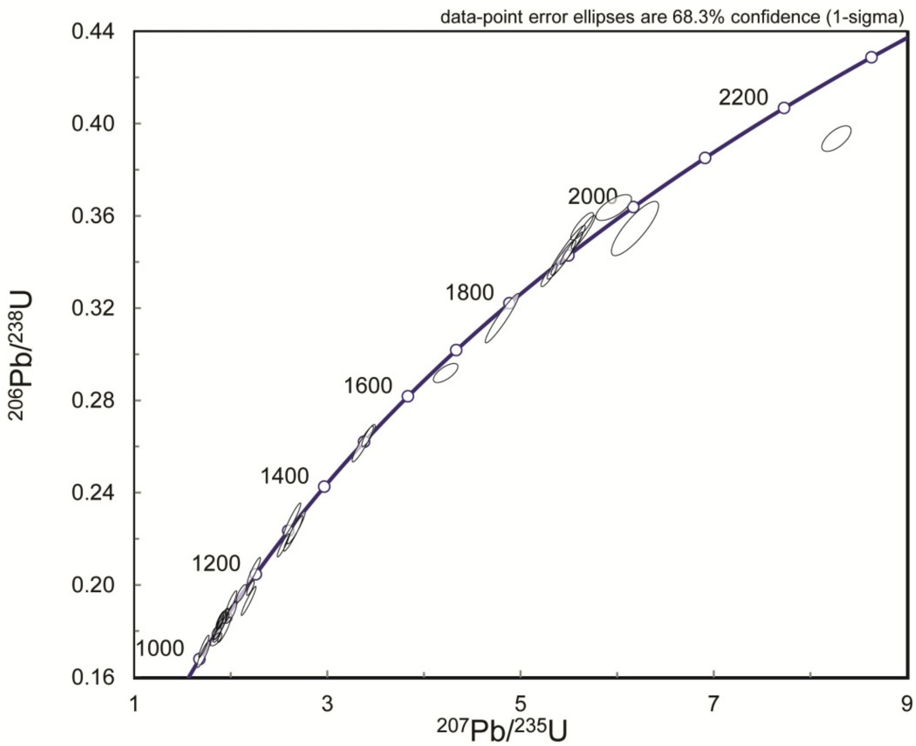


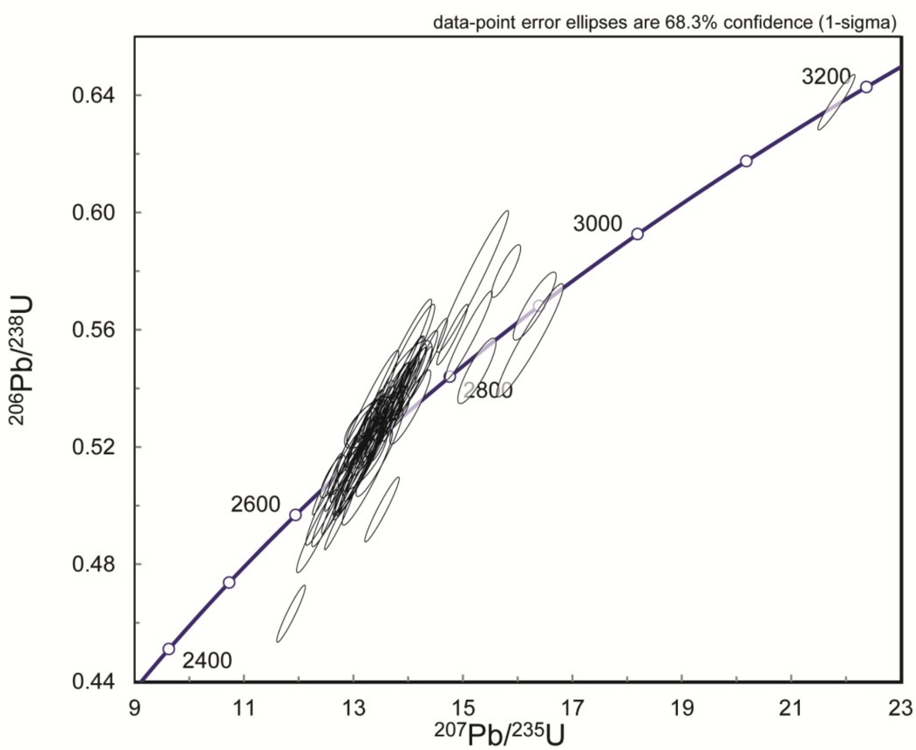
Sample BT – Lower Basal Tulip Creek Sandstone



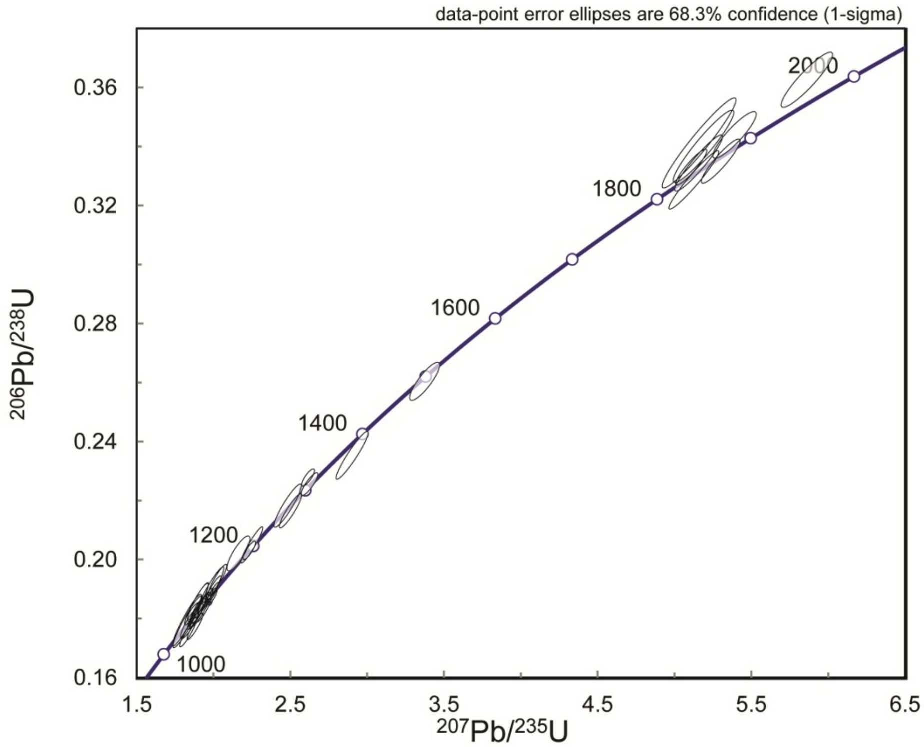


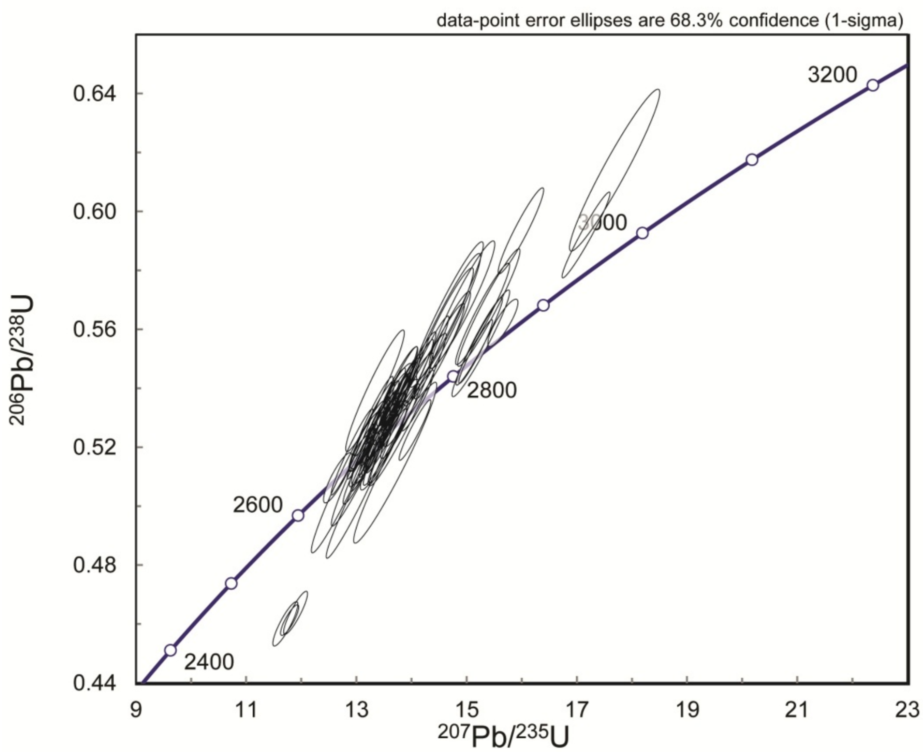
Sample TCT – Upper Basal Tulip Creek Sandstone





Sample S5 – Lower St. Peter Sandstone





Sample AS2 – Upper St. Peter Sandstone